Population Structure and Habitat Use of

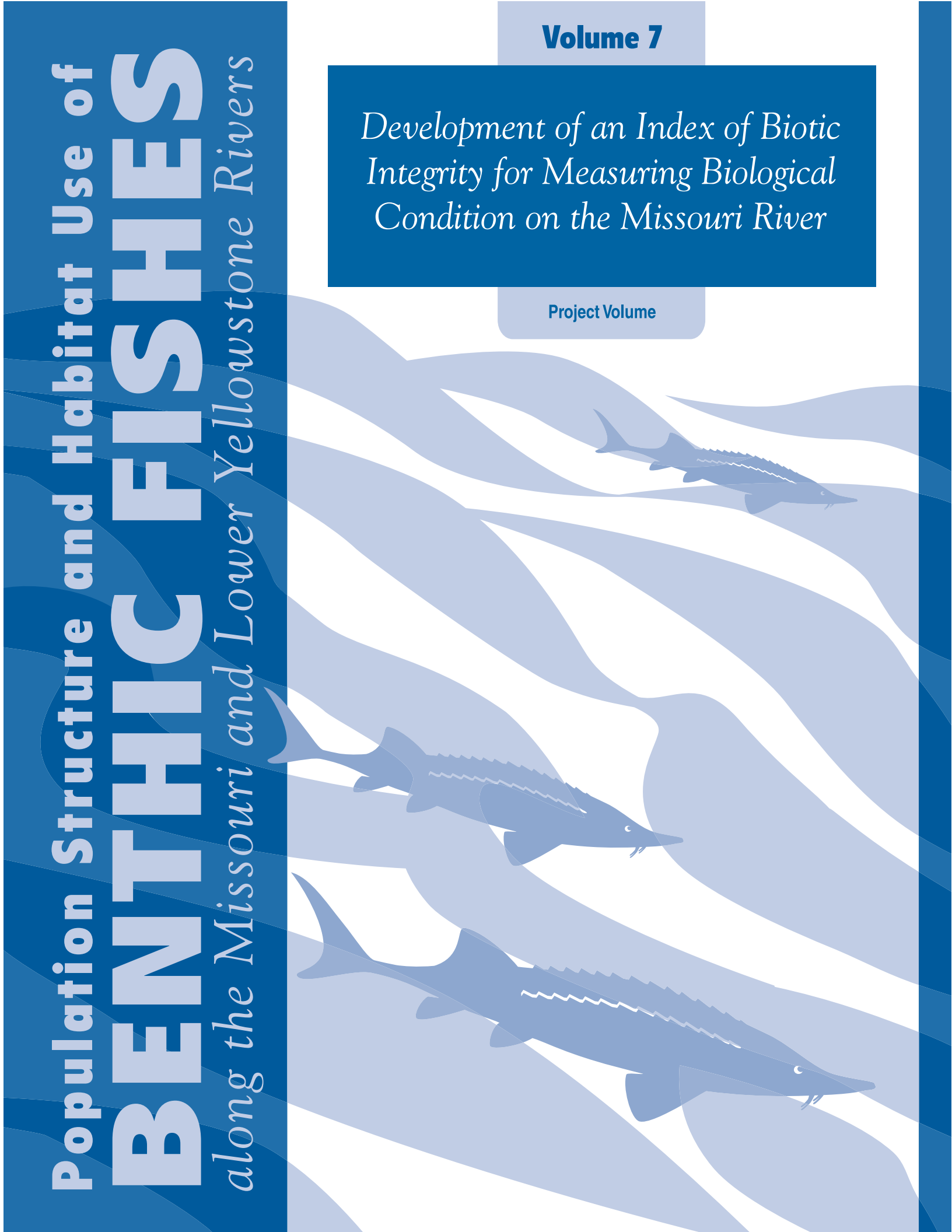
BENTHIC FISHES

along the Missouri and Lower Yellowstone Rivers

Volume 7

Development of an Index of Biotic Integrity for Measuring Biological Condition on the Missouri River

Project Volume



Development of an Index of Biotic Integrity for Measuring Biological Condition on the Missouri River

Volume 7

Population Structure and Habitat Use of Benthic Fishes Along the Missouri and Lower Yellowstone Rivers

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PREFACE

Population Structure and Habitat Use of Benthic Fishes along the Missouri and Lower Yellowstone Rivers

This research is reported in the 12 volumes listed below. Reports are available through the U.S. Army Corps of Engineers, the primary contracting agency for the overall project. Contact: Becky Latka, U.S. Army Corps of Engineers, CENWO-PM-AE, 106 South 15th Street, Omaha, NE 68102, (rebecca.j.latka@usace.army.mil; 402/221-4602) for paper copies, or access online in PDF format at http://www.nwo.usace.army.mil/html/pd-e/benthic_fish/benthic_fish.htm. Anticipated date of publication is in (parentheses) for volumes not yet available. Please use the citation format suggested here without the email address when referencing Final Report volumes.

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Galat, D. L., M. L. Wildhaber, and D. J. Dieterman. 2001. Spatial patterns of physical habitat. Volume 2. Population structure and habitat use of benthic fishes along the Missouri and lower Yellowstone rivers. U.S. Geological Survey, Cooperative Research Units, University of Missouri, 302 ABNR Bldg., Columbia, Missouri 65251-7240. galatd@missouri.edu

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Pierce, C. L., C. S. Guy, P. J. Braaten, and M. A. Pegg. 2004. Fish growth, mortality, recruitment, condition, and size structure. Volume 4. Population structure and habitat use of benthic fishes along the Missouri and lower Yellowstone rivers. U.S. Geological Survey, Cooperative Research Units, Iowa State University, Science Hall II, Ames, Iowa 50011. cpierce@iastate.edu

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Braaten, P. J. 2000. Growth and mortality of fishes in the Missouri River, with emphasis on freshwater drum. Doctoral Dissertation, Kansas State University, Manhattan, Kansas. [Volume 8. Population structure and habitat use of benthic fishes along the Missouri and lower Yellowstone rivers.]

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Young, B. A. 2001 Intraspecific variation among emerald shiners (*Notropis atherinoides*) of the Missouri River. Doctoral Dissertation, South Dakota State University, Brookings, South Dakota. [Volume 11. Population structure and habitat use of benthic fishes along the Missouri and lower Yellowstone rivers.]

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EXECUTIVE SUMMARY

An index of biotic integrity was developed for the warmwater riverine reaches of the Missouri River in order to determine changes in the biological condition of the river related to channelization and impoundment effects. Data were collected from 1995 through 1998 as part of the Missouri River Benthic Fish Study with support from the U.S. Army Corps of Engineers, the U.S. Geological Survey, and several state universities. The least altered or reference condition was defined by sites on the Missouri River upstream of Fort Peck Reservoir and sites on the lower Yellowstone River. Disturbed conditions were defined from sites in the inter-reservoir (regulated), channelized, and regulated-unchannelized zones of the river. The fish assemblage was characterized based on species composition, relative abundance, species richness, historical distributions, reproductive strategies, feeding guilds, habitat preference, and tolerance or intolerance to environmental disturbance. A total of 19 metrics were examined for possible inclusion in the Missouri River index of biotic integrity. Each metric was examined for responsiveness, redundancy, and variability.

All 19 of the candidate metrics could discriminate between the least-altered zone and at least one other river zone and metrics were generally not redundant with one another. Metric variability was high (CV exceeding 100%) for three candidate metrics; percent catostomids, percent round-bodied suckers, and percent individuals with deformities, erosion, lesions, or tumors (DELT). Variability in these metrics was reduced when metric scores were analyzed instead of raw data. Twelve metrics were chosen for the final index based on the attributes mentioned above as well as individual metric performance in previously published indices.

The final 12 metrics were: 1) number of native species, 2) percent large river faunal group, 3) number of native cyprinids, 4) percent round-bodied catostomids, 5) number sensitive species, 6) percent tolerant individuals, 7) percent detritivores and filter-feeders, 8) percent insectivorous cyprinids, 9) percent top carnivores, 10) catch per unit effort, 11) percent introduced individuals, and 12) percent DELT. Based on a preliminary rating of total index scores, the least-altered zone was rated excellent to good at all sites. The inter-reservoir zone showed greatest variability in ratings with some sites being rated excellent (3%), good (37%), fair (32%), poor (25%), and very poor (3%). The regulated-unchannelized zone had sites rated good (60%), fair (33%), and poor (7%). The channelized zone had sites rated good (31%), fair (58%), and poor (11%).

Further testing of the Missouri River index of biotic integrity is needed in order to determine the overall validity of the index. Sites with known, varying degrees of anthropogenic disturbance should be sampled in multiple years to verify that the index consistently places sites in their correct rating category and to better determine the temporal variability of the index. Additional data collection will also refine scoring criteria for the index.

The Missouri River index of biotic integrity holds a great deal of promise in aiding researchers and managers in such tasks as identifying areas of high biological condition in need of preservation, identifying areas where rehabilitation or mitigation is warranted, and evaluating the effectiveness of mitigation and rehabilitation efforts.

Keywords: feeding guild, fish assemblage, Index of Biotic Integrity, large river fishes, Missouri River, native fishes, reproductive guild, Yellowstone River

TABLE OF CONTENTS

PREFACE....ii
EXECUTIVE SUMMARY....iv
TABLE OF CONTENTS....vi
LIST OF FIGURES....vii
LIST OF TABLES....1
INTRODUCTION....3
STUDY AREA....3
METHODS....3
- Fish Collection....3
- Reference and Disturbed Condition....6
- Fish Assemblage Characterization....7
- Candidate Metrics....7
  - *Total Number of Native Species*....7
  - *Percent of Large River Faunal Group*....7
  - *Number of Native Cyprinid Species*....8
  - *Number of Catostomid Species*....10
  - *Percent Catostomids*....10
  - *Percent Round-Bodied Catostomids*....10
  - *Number of Sensitive Species*....10
  - *Percent Sensitive Species*....10
  - *Percent Tolerant Species*....10
  - *Percent Detrivores and Filter-Feeding Herbivores and Planktivores*....10
  - *Percent Insectivorous Cyprinids*....10
  - *Percent Benthic Insectivores*....11
  - *Percent Top Carnivores*....12
  - *Catch Per Unit Effort (CPUE)*....12
  - *Percent Introduced Individuals*....12
  - *Percent Pelagophilous spawners*....12
  - *Percent Lithopelagophilous spawners*....15
  - *Percent Pelagophilous and Lithopelagophilous spawners*....15
  - *Percent Deformities, Erosions, Lesions, and Tumors (DELT*)....15
- Metric Responsiveness....15
- Metric Redundancy....15
- Metric Variability....16
- Metric Scoring and Index Construction....16
- Metric Contribution to Index Score....16

RESULTS AND DISCUSSION....18
- Metric Responsiveness....18
- Metric Redundancy....18
- Metric Variability....18
- Metric Scoring and Index Construction....18
- Biological Condition on the Missouri River....32
- Metric Contribution to Index Score....33

LIMITATIONS AND RECOMMENDATIONS....34
ACKNOWLEDGMENTS....34
REFERENCES....36
APPENDIX A....41

LIST OF FIGURES

Figure 1. Map of the Missouri River basin showing study segments....4
Figure 2. Box plot of the percent of individuals of the large river faunal group by river zone....19
Figure 3. Box plot of the number of sensitive species by river zone....19
Figure 4. Box plot of the percent of individuals made up of sensitive species by river zone....20
Figure 5. Box plot of the percent of individuals made up of insectivorous cyprinids by river zone....20
Figure 6. Box plot of the percent of individuals made up of tolerant species by river zone....21
Figure 7. Box plot of the number of catostomid species by river zone....21
Figure 8. Box plot of the percent of individuals made up of round-bodied catostomids by river zone....22
Figure 9. Box plot of the percent of individuals made up of top carnivores by river zone....22
Figure 10. Box plot of catch per unit effort (fish/km) by river zone....23
Figure 11. Box plot of the percent of individuals made up of pelagophilous spawners by river zone....23
Figure 12. Box plot of the percent of individuals made up of detritivores, filter-feeding herbivores, and filter feeding planktivores by river zone....24
Figure 13. Box plot of the percent of individuals made up of catostomid species by river zone....24
Figure 14. Box plot of the percent of individuals made up of benthic insectivores by river zone....25
Figure 15. Box plot of the percent of individuals made up of lithopelagophilous spawners by river zone....25
Figure 16. Box plot of the percent of individuals made up of lithopelagophilous and pelagophilous spawners by river zone....26
Figure 17. Box plot of the number of native species by river zone....26
Figure 18. Box plot of the number of native cyprinid species by river zone....27
Figure 19. Box plot of the percent of individuals made up of introduced species by river zone....27
Figure 20. Box plot of the percent of individuals with deformities, erosions, lesions, or tumors by river zone....28
Figure 21. Scatter plot of the number of native species by river kilometer....28
Figure 22. Scatter plot of the number of native cyprinid species by river kilometer....29
Figure 23. Scatter plot of the number of catostomid species by river kilometer....29
Figure 24. Scatter plot of the number of sensitive species by river kilometer....30
Figure 25. Box plot of IBI scores by river zone....32

LIST OF TABLES

Table 1. List of study segments and corresponding river zones.....5
Table 2. Candidate metrics and ability of metrics to discriminate between reference sites and disturbed sites in inter-reservoir, regulated-unchannelized, and channelized zones in the Missouri River basin.....8
Table 3. Species collected in the Missouri and lower Yellowstone River that were classified as members of the large river faunal group.....9
Table 4. Species collected in the Missouri and lower Yellowstone River that were classified as tolerant species....11
Table 5. Species collected in the Missouri and lower Yellowstone River that were classified as detritivores, filter-feeding herbivores, or filter-feeding planktivores.....12
Table 6. Cyprinid species collected in the Missouri and lower Yellowstone River that were classifiedas insectivores.....13
Table 7. Species collected in the Missouri and lower Yellowstone River that were classified as benthic insectivores.....14
Table 8. Species collected in the Missouri and lower Yellowstone River that were classified as top carnivores...15
Table 9. Species collected in the Missouri and lower Yellowstone River that were classified as pelagophilous spawners.....16
Table 10. Species collected in the Missouri and lower Yellowstone River that were classified as lithopelagophilous spawners.....17
Table 11. Equations used for scoring individual IBI metrics.....31
Table 12. Relative contributions to the overall IBI score for least-altered and disturbed zones for each of the 12 metrics.....33

INTRODUCTION

The Missouri River flows 3,768 km along a southeastern course from southwestern Montana to the Mississippi River. Historically, the warmwater portion of the Missouri River from north-central Montana, to near St. Louis, Missouri, was characterized by eroding banks, braiding and shifting channels, and numerous sandbar and island complexes (Hesse et al. 1989). Modifications to the ecological integrity of the natural Missouri River-floodplain ecosystem from impoundment and reservoir operation, channelization and channel maintenance, flood control, and water pollution have been widespread for nearly 170 years (reviewed in Hesse 1987; Schmulbach et al. 1992; Scientific Assessment and Strategy Team 1994).

Earliest large-scale modifications began in 1832 when snags were removed to facilitate steamboat traffic on the river (Funk and Robinson 1974). By the turn of the century, steamboat traffic came to an end on the Missouri River and the United States Army Corps of Engineers began taking responsibility for channelization and stabilization efforts on the river. From 1912 to 1967, a navigation channel 2.7 m deep and 91.4 m wide was constructed from St. Louis, Missouri, to Sioux City, Iowa, to allow barge traffic on the Missouri River (Funk and Robinson 1974). This reach became a uniform rock-lined channel contained within levees, varying in width from 183 to 335 m, as compared to historic flood plain widths of 2.4 to 27.4 km (Funk and Robinson 1974). During this time, six mainstem dams impounding 1,202 km of riverine habitat were also constructed along the warmwater portion of the river from northeastern Montana to Nebraska. An additional 1,300 water control projects were constructed on the Missouri River on at least 95 Missouri River tributaries (Hesse et al 1989; Galat et al. 1996).

With nearly one third of the entire Missouri River impounded and another one third channelized, the changes to the river and floodplain habitats and their biota have been extreme. The direct effects of impoundment are obvious. It has inundated the shallow, meandering river, its side channels and ox-bows, and its riparian community into a deep, standing lentic environment completely foreign to most of the native fauna of the Missouri River. Dams have decreased suspended sediment loads by 67 to 99% in the lower river with a corresponding decrease in turbidity (Galat et al. 1996).

The natural hydrograph of the Missouri River has also been altered. Spring peak flows have been greatly reduced with a much more stable hydrograph during the navigation season (April to November) than historically (Galat et al. 1996). The magnitude and duration of the annual flood pulse has been dampened since closure of the reservoirs (Galat and Lipkin 2000; Pegg 2000; Pegg and Pierce 2002a). During the period of record, flushing flows (flows that exceed bankfull discharge) have been reduced in frequency from 15 of 24 pre-dam years to 2 of 33 years following closure of the last dam (Galat et al. 1996). Changes in the hydrograph have resulted in a loss of off-channel habitat, reduced bar development and connection to the flood plain, and loss of reproductive cues for many native fishes (Hesse 1996). Tailwater releases have also reduced water temperatures in summer and caused severe channel incision. All of these changes have served to alter reproductive cues of fish and reduce the availability of slow, shallow habitats.

Channelization has occurred throughout the lower one-third of the river for barge traffic and flood protection for agricultural lands and urban areas. It has resulted in increased depth and velocity, and decreased island development, off-channel habitat, reach length, and nutrient inputs from the floodplain. Between 1879 and 1972 in the reach of the Missouri River from Rulo, Nebraska, to the confluence of the Mississippi River, river length decreased 8% (73.4 km), surface area decreased 50% (24,636 ha), and island surface area decreased 98% (9,713 ha; Funk and Robinson 1974).

The effects of channelization and impoundment on the Missouri River fishery have been documented through commercial fishery records and sporadic research in various reaches of the river. Prior to 1945, few extensive fish collections were made on the Missouri River and some commercial fishery data was collected (Funk and Robinson 1974). The data that are available indicate that commercial harvest on the Missouri River declined by 80% from 1947 to 1963 (Funk and Robinson 1974).

Many native fishes are jeopardized by past and present management practices on the Missouri River (Hesse et al. 1993b). Over 20 species are currently listed as rare, threatened, or of special concern by states or the federal government (Scientific Assessment and Strategy Team 1994). Currently, only the pallid sturgeon (*Scaphirhynchus albus*) is listed as federally endangered. An additional eight species (lake sturgeon, *Acipenser fulvescens*; blue sucker, *Cycleptus elongatus*; western silvery minnow, *Hybognathus argyritis*; plains minnow, *H. placitus*; sturgeon chub, *Macrhybopsis gelida*; sicklefin chub; *M. meeki*; flathead chub, *Platygobio gracilis*; and paddlefish, *Polyodon spatula*) are proposed or considered possibly appropriate for listing by the U.S. Fish and

Wildlife Service (i.e., previous Category 1 and 2 designations before the designations were discontinued).

Population status of fishes at risk within the Missouri River varies geographically. The healthiest fish populations persist in the upper, relatively unaltered Missouri River and its major tributaries (Hesse et al. 1989; White and Bramblett 1993). Greatest population declines are in the middle and lower Missouri River in areas of degraded channels downstream from mainstem reservoirs (Hesse and Mestl 1993); the fish assemblage there has been characterized as demonstrating more generalist characteristics than other reaches of the river (Pegg and Pierce 2002b). The lower Missouri River may be somewhat intermediate as Pflieger and Grace (1987) found stable populations of several species that Hesse (1996) reported declining in Nebraska.

Factors responsible for these apparent longitudinal differences are not immediately apparent. Attempts to implement general (Berry and Galat 1993) and specific strategies (e.g., Hesse and Mestl 1993; Hesse and Sheets 1993; Hesse et al. 1993a) to restore a naturally functioning Missouri River-floodplain ecosystem have been hampered by limited knowledge of habitat requirements, population dynamics, and assemblage structure of fish resources within the basin. Implementation of restoration goals requires an ecosystem perspective and a method of assessing restoration efforts that gauges success based on the potential biological health of the system. One such tool to assess restoration efforts based on the fish assemblage is the index of biotic integrity (IBI).

The IBI has proven to be a valuable biological assessment tool for evaluating the status and restoration of aquatic ecosystems (Fausch et al. 1990; Karr and Chu 1999). It is based on a long history of using biological communities to protect and manage water resources. Such methods can be traced back nearly 150 years (Davis 1995). Fishes have commonly been used as bioassay organisms but only in the last two decades have whole fish assemblages been used as indicators of environmental degradation (Karr 1981). Fishes are good organisms for measuring environmental degradation because they are sensitive to a variety of stresses, integrate effects of various stresses, demonstrate effects of reproductive failure in several age classes, and facilitate evaluation of societal costs because of their recognized economic and aesthetic values (Fausch et al. 1990).

The IBI was originally developed for small, warmwater, midwestern streams (Karr 1981). Karr (1981) proposed 12 metrics related to species richness and composition, trophic composition, and fish abundance and condition. The 12 metrics were scored with values of 5, 3, and 1 based on whether the value approximated, deviated somewhat, or deviated strongly from the value expected at a comparable, relatively undisturbed, site (Miller et al. 1988). Based on the total IBI score, a site was then rated as excellent, good, fair, poor, very poor, or no fish.

Since the initial development of the IBI, it has been modified for a variety of regions and habitats (Miller et al. 1988; Fausch et al. 1990; Simon and Lyons 1995; Hughes and Oberdorff 1999) and has proven to be a valuable tool for assessing the status of aquatic communities (Karr and Chu 1999). The general framework of the IBI includes the development of expected conditions of the structure, composition, and functional organization of the biota without substantial environmental degradation. Collection of empirical data then allows for the comparison of current condition to the expected reference "benchmark" used for deciding if a system is healthy or unhealthy (Hughes 1995).

The development of multimetric approaches for evaluating environmental degradation in large rivers has progressed slowly because of concerns with sampling efficiency, representative sampling, and lack of undegraded large river reaches for establishing reference conditions (Fausch et al. 1984; Simon and Lyons 1995; Reash 1999). The IBI has been modified and applied to large river ecosystems with varying degrees of success (Hughes and Gammon 1987; Ohio EPA 1987a; Ohio EPA 1987b; Hoefs and Boyle 1992; Oberdorff and Hughes 1992; Simon and Emery 1995; Emery et al. 1999; Simon and Sanders 1999; Lyons et al. 2001; Emery et al. 2003; Mebane et al. 2003).

With the substantial modifications that have occurred on the Missouri River and the increasing concern over fish and wildlife values on the river, a need exists to establish an effective biological assessment tool to describe the current status of the biota and measure the response to any remediation efforts or changes in water management practices. The three main objectives of this investigation were to 1) characterize the fish assemblage of the warmwater riverine reaches of the Missouri River, 2) develop a numeric multimetric index of biotic integrity to describe the changes associated with major river modifications along all warmwater riverine reaches of the Missouri River, and 3) identify the appropriateness of this method for long-term use on the Missouri River system. This study tested the broad hypothesis that biotic integrity declined in reaches with increased environmental degradation in the Missouri River. Answering several more-specific hypotheses tested this general

hypothesis (e.g., species with specialized feeding requirements decline in reaches with increased environmental degradation).

This study was part of a USACOE funded basin-wide effort between the Cooperative Research Units in Montana, Idaho, South Dakota, Iowa, Kansas, and Missouri (Missouri River Benthic Fish Consortium, MRBFC), and Montana Department of Fish, Wildlife, and Parks (MFWP). The base study was designed to 1) describe and evaluate recruitment, growth, size structure, body condition, and relative abundance of selected benthic fishes within and among river zones and among study segments, and 2) describe habitat use of benthic fishes along the entire mainstem warmwater riverine portion of the Missouri River.

STUDY AREA

The study encompassed all warmwater riverine reaches of the Missouri River from Fort Benton, Montana, (rkm 3303.0) to the Mississippi River confluence (rkm 0.0) near St. Louis, Missouri, the mouths of major tributaries along these reaches, and the lower Yellowstone River from Intake Diversion Dam (rkm 114.2) near Glendive, Montana, to the Missouri River confluence (rkm 0.0) near Fairview, Montana (Figure 1). The study area was characterized *a priori* into three river zones. They were 1) least-altered, including the upper Missouri and lower Yellowstone rivers 2) Missouri River inter-reservoir, and 3) Missouri River channelized. For data analysis for the IBI development, the Missouri River from Gavins Point Dam to Ponca, Nebraska, was removed from the inter-reservoir zone and put into a separate fourth zone, the Missouri River regulated-unchannelized. This was done due to the unique habitat and fauna characteristics of this reach that were not characteristic of the other inter-reservoir reaches. These zones were divided into 27 segments based on geomorphic and constructed features (e.g., major tributaries, dams; Table 1).

METHODS

Fish Collection

Fish were collected from main channel macrohabitats with a variety of gears. Each macrohabitat was sampled at five locations each year (1996-1998) within a subset of the 27 segments (Table 1). The sampling approach was identical in each river segment. Sampling repetitions and sampling time or sampling distance or both were standardized as much as logistically possible. Specific definitions, sampling design, and design and deployment of gear information are described in greater detail by Sappington et al. (1998).

The three main channel macrohabitats sampled were channel cross-over, outside bend, and inside bend. Channel cross-overs were sampled using a trammel net and a benthic trawl. Each gear was deployed two to three times at each sampling site and sampled 150 to 300 m depending on habitat length and safety considerations. Outside bends were also sampled with a trammel net and benthic trawl along with boat electrofishing along the shore for one run of 15 to 30 minutes.

Inside bends were sampled with a trammel net and a benthic trawl along the channel border. If a well-developed wadeable sand bar was present, a bag seine was deployed two to three times along the shoreline using a ½ arc. If the inside bend consisted of a steep bank that precluded seining, one boat electrofishing run of 15 to 30 minutes was conducted. These three continuous macrohabitats were all sampled on the same "river bend" on the same sampling occasion. The three main channel macrohabitats are collectively referred to as "main channel" sampling hereafter.

All fish except *Hybognathus* species were identified to species, enumerated, weighed to the nearest ±1 g and measured to the nearest ±1 mm. Three species of the genus *Hybognathus* are present in the Missouri River. The western silvery minnow (*Hybognathus argyritis*) and the plains minnow (*Hybognathus placitus*) were recorded as *Hybognathus* species because the two species are difficult to identify in the field. The two species appear to be ecologically similar in food habits and habitat preferences (Appendix A). The brassy minnow (*Hybognathus hankinsoni*) was identified to species.

If time constraints did not allow for all fish to be weighed and measured, a subset of each species was weighed and measured. All data were recorded on standardized data sheets (Sappington et al. 1998).

Reference and Disturbed Condition

Knowledge of biogeographical information and assemblage structure of the fish fauna in relatively unaltered regions (i.e., reference condition) helps discriminate between natural changes in assemblage structure and those induced by anthropogenic effects. Reference conditions are based on regional areas that are relatively unaltered, historical data, quantitative models, and best professional judgment (Hughes 1995).

All sites on the Missouri River in the least-altered zone (including the lower Yellowstone River) were considered reference sites. This portion of the

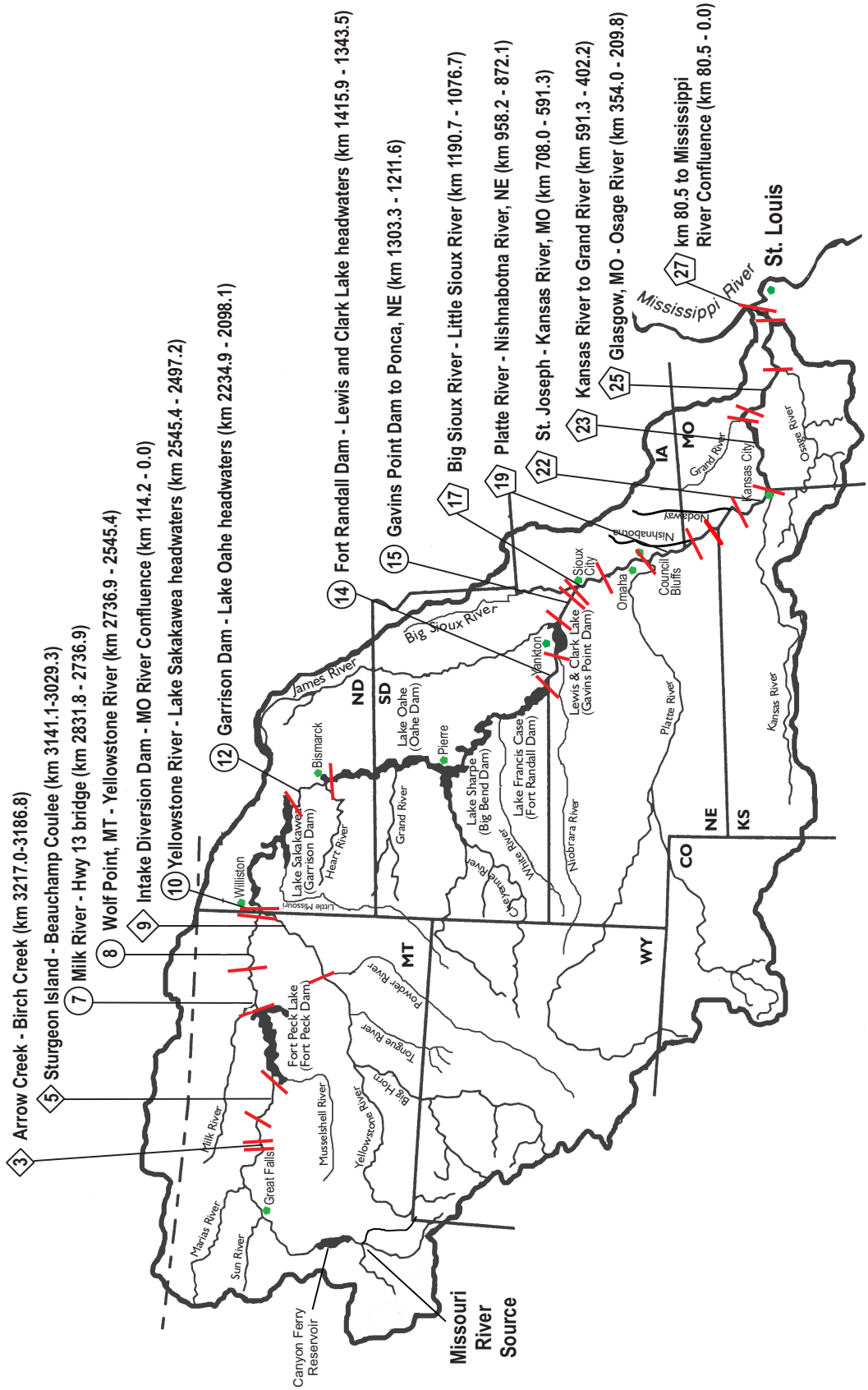

Figure 1. Map of Missouri River basin showing general locations of 15 segments sampled for physical variables from mid-June to October, 1996-1998. Segment numbers within diamonds are in the least-altered zone, numbers in circles are segments in the inter-reservoir zone, and numbers in pentagons are segments in the channelized zone. (map produced by J. Heuser, USGS, CERC).

Table 1. List of study segments, corresponding river zones (CH = channelized, IR = inter- reservoir, LA = least-altered, RU = regulated-unchannelized), location description, corresponding river kilometer, and years sampled (NS = not sampled).

Segment	Zone	Description	River km	Years Sampled
1	LA	Loma Ferry - Rattlesnake Coulee	3303 – 3255	NS
2	LA	Rattlesnake Coulee - Arrow Cr.	3255 – 3217	NS
3	LA	Arrow Cr. - Birch Cr.	3217 –3187	1996-1998
4	LA	Birch Cr. – Sturgeon Island	3187 – 3141	NS
5	LA	Sturgeon Island – Fort Peck	3141 – 3029	1996-1998
6	IR	Fort Peck Dam – Milk R.	2848 – 2832	NS
7	IR	Milk R. – Wolf Point, MT	2832 – 2737	1996-1998
8	IR	Wolf Point, MT – Yellowstone R.	2737 – 2545	1996-1998
9	LA	Yellowstone River (Intake Diversion Dam – Missouri R.)	114 – 0	1996-1998
10	IR	Yellowstone R. – L. Sakakawea Headwaters	2545 – 2497	1996-1998
11	IR	L. Sakakawea Headwaters – L. Sakakawea	2497 – 2470	NS
12	IR	Garrison Dam – L. Oahe Headwaters	2235 – 2098	1996-1998
13	IR	L. Oahe Headwaters – L. Oahe	2098 – 2051	NS
14	IR	Ft. Randal Dam – Lewis and Clark L. Headwaters	1416 – 1344	1996-1998
15	RU	Gavins Point Dam – Ponca, NE	1303 – 1212	1996-1998
16	CH	Ponca, NE – Big Sioux R.	1212 – 1191	NS
17	CH	Big Sioux R. – Little Sioux R.	1191 – 1077	1996-1998
18	CH	Little Sioux R. – Platte R.	1077 – 958	1996
19	CH	Platte R. – Nishnabotna R.	958 – 872	1996-1998
20	CH	Nishnabotna R. – Rulo, NE	872 – 801	NS
21	CH	Rulo, NE – St. Joseph, MO	801 – 708	1996
22	CH	St. Joseph, MO – Kansas City, MO	708 – 591	1996-1998
23	CH	Kansas City, MO – Grand River, MO	591 – 402	1996-1998
24	CH	Grand River, MO – Glasgow, MO	402 - 354	NS
25	CH	Glasgow, MO – Osage R.	354 – 210	1996-1998
26	CH	Osage R. – RKM 81	210-81	NS
27	CH	Rkm 80.5 – Mississippi R.	81 – 0	1996-1998

Missouri River is only minimally impacted by impoundments and the Yellowstone River is free flowing throughout its entire length. Both rivers are only minimally affected by urbanization as well. These reaches of these two rivers represent the best-attainable conditions (Barbour et al. 1996) for the warmwater zone of the Missouri River.

The warmwater zone of the Missouri River covers 3300 km and crosses seven ecoregions (Omernik 1987). All least-altered, or reference, areas occur in the upper basin upstream of Fort Peck Reservoir in the Northwestern Great Plains and the Northwestern Glaciated Plains. The river continues through the Northeastern Great Plains, Northern Glaciated Plains, Western Corn Belt Plains, Central Irregular Plains, and the Interior River Lowlands. Whereas concerns exist about predicting assemblage structure across such distances, it has been noted that large river ecosystems are little affected by ecoregion changes (Hughes 1995) and changes in species composition along a longitudinal gradient from upstream to downstream in warmwater unregulated rivers consist of species additions with less frequent deletions (Rahel and Hubert 1991). Therefore, species richness can be assumed to increase in a downstream direction. Proportional composition of the assemblage may be expected to remain relatively constant given equal habitat characteristics. Whereas the habitat characteristics of the Missouri River do change because of anthropogenic effects (dams, channelization, etc.), historical accounts of the Missouri River indicate habitats throughout the warmwater portion of the Missouri River were similar throughout its course (Hesse et al. 1989). Given this theoretical framework, reference condition can be hypothesized based on the relatively static proportions of various parameters of the assemblage (e.g., feeding guilds, reproductive guilds) whereas measures of richness would be expected to increase along a longitudinal gradient.

To minimize the effects of river size, selection of candidate metrics focused on metrics based on percentages rather than species richness (see Candidate Metrics below). For metrics based on percentages of some aspect of the fish assemblage, the 75th percentile of the least-altered sites were chosen to represent the final reference condition for the Missouri River. Nevertheless, some species richness metrics were necessary to keep the ecological framework of the IBI intact.

Typically, reference condition is defined by comparing reference sites of different stream sizes to determine the relationship between stream size and maximum species richness (Fausch et al. 1984; Rankin and Yoder 1999). However, all reference sites for the Missouri River are located in the upper basin, making the analysis of the reference condition across varying river size impossible. To develop reference condition for the species richness metrics, the 75th percentile of the reference sites was used to determine the reference condition in the upper basin. A scatter plot of the total number of species for all sampling sites was then examined to determine the approximate relationship between distance from the mouth and species richness. A linear relationship was then fitted based on the 75th percentile of the least-altered segments and the highest observed species richness values for altered sites.

In order to increase sample size for data analysis, data from segments were pooled and analyzed by zone. This resulted in sample sizes of 45, 75, 15, and 100 for the least-altered, inter-reservoir, regulated-unchannelized, and channelized zones, respectively. The pooling of segment data was done to observe the full range of variability associated with each of the individual river zones.

Fish Assemblage Characterization

The basic premise of the IBI is that fish assemblage structure reflects direct and indirect effects of stress on the entire aquatic ecosystem and the investigation of assemblage structure can help identify the significance of environmental disturbance (Simon 1999a). To fully understand the implications of changes in fish assemblage structure caused by disturbance, the accurate description and classification of several characteristics of the fish fauna is needed. These characteristics include a basic description of the species composition, a measure of relative abundance, species richness, historical distributions, reproductive guilds (Simon 1999b), feeding guilds (Goldstein and Simon 1999), habitat preferences, and tolerance or intolerance to environmental perturbation.

Reproductive, feeding, and habitat guilds have often been used as indicators of environmental degradation (Fausch et al. 1990). Generally, environmental degradation is indicated by shifts from specialized guilds (e.g., benthic invertivore) to generalized guilds (e.g., omnivore).

Each species captured during this investigation of the Missouri River was classified based on native distribution (i.e., native or introduced), reproductive guild (Simon 1999b), feeding guild (Goldstein and Simon 1999), macrohabitat preference, and tolerance or intolerance to environmental perturbation (Appendix A).

The native distribution of each species was based on several regional fish keys, general fish keys, and

published manuscripts (Appendix A). Because exact limits to historical distribution are uncommon, native distributions were classified at the segment level. Discrepancies in the historical native ranges of some species were occasionally encountered. These occurred because of poor historical documentation of some species as well as the documented and undocumented transport of game and forage fish within the basin. A liberal approach was applied when such discrepancies occurred (i.e., if one reference indicated the species was native to a particular segment, it was classified as native to that segment even if other references indicated it was not native). This probably resulted in some species being considered native to segments where they were historically absent and would potentially result in higher IBI scores for some sites.

Reproductive guild classification was based on the framework developed by Balon (1975; 1981; 1985) who classified fish reproduction based on embryonic development, early life history characteristics, spawning media, and reproductive behavior. All fish can be classified as nonguarders (open substrate spawners or brood hiders), guarders (substrate choosers or nest spawners), or bearers (external or internal) with additional finer resolution classifications under each category. Classification of Missouri River fishes follows Simon (1999b) except where noted (Appendix A).

Fish were placed into feeding guild categories based on the classification scheme proposed by Goldstein and Simon (1999), who defined five trophic classes (herbivore, detritivore, planktivore, invertivore, and carnivore), nine trophic subclasses, and 26 modes of feeding. Fish were classified following Goldstein and Simon (1999) except where noted (Appendix A).

Detailed habitat use and preference information is lacking for many of the species sampled. Therefore, each species was categorized broadly as whether or not it was (1) a large river specialist, and (2) a benthic species. Large river specialists, or the large river faunal group (Pflieger 1971) are species generally only found in large rivers and are often affected by large-scale habitat changes such as channelization, dredging, and the destruction of wetlands (Simon and Emery 1995). Benthic species, or bottom-associated species, were chosen because of large declines in abundance of benthic fish species in the Missouri River (seven of eight species proposed or considered possibly appropriate for listing by the USFWS).

Species were defined as tolerant or intolerant only if published literature or regional fish keys listed specific tolerances to environmental perturbations that were pertinent to the Missouri River (e.g., channelization, flow regulation). Species were also defined as intolerant if substantial declines in abundance or range have been documented, whether the particular mechanisms responsible for their declines are understood or not.

Candidate Metrics

Pooled main channel data were used for the selection of metrics. Other macrohabitats were sampled by the MRBFC (e.g., side channels, tributary mouths) but were sampled separately and did not correspond to main channel sites (i.e., off channel habitats were not sampled at the same location and therefore could not be considered part of a site). Therefore, these data were removed from the data set.

We examined 19 candidate metrics used in other indices or developed specifically for the Missouri River (Table 2). A description and rationale for each candidate metric is given below.

Total Number of Native Species. Total number of species or total number of native species has been used as metric in nearly every IBI developed (Simon and Lyons 1995; Lyons et al. 2001). The number of fish taxa in warmwater streams and rivers of similar size within a specific region will decrease with increased anthropogenic stress (Karr et al.1986). Whereas some have argued for the inclusion of introduced species because of their irreversible presence in river ecosystems (Simon and Emery 1995), Karr et al. (1986) contend that introduced species may represent a loss of biological integrity, especially if introduced species are replacing native species. We believed that introduced species represent a form of anthropogenic stress and that the exclusion of introduced species would make a more sensitive metric. Therefore, the total number of species was not considered further.

Percent Large River Faunal Group

The percentage of total catch that is made up of members of the large river faunal group (Table 3) was used in the original IBI for the Ohio River (Simon and Emery 1995). The large river faunal group refers to the characteristic fauna associated almost exclusively with large rivers (Pflieger 1971; Smith et al. 1971; Cross et al. 1986; Matthews and Robison 1988). Decreases in the percentage of the large river faunal group are indicative of habitat destruction, which reduces spawning, nursery, and feeding habitats of these species. This metric replaces the original IBI metric, number of darter species, which was indicative of declines in specialized benthic species (Karr 1981).

Table 2. Candidate metrics and ability of metrics to discriminate ($p < 0.05$) between reference sites (N = 45) and disturbed sites in inter-reservoir (IR: N = 75), regulated-unchannelized (RU; N=15), and channelized (CH; N = 100) zones in the Missouri River basin. Metrics used in final IBI are in **bold**.

Metric	Predicted response to environmental stress	Zones significantly different than reference sites in predicted direction
Number Native Species	Decrease	IR
Percent Large River Faunal Group	Decrease	CH, IR, RU
NumberNative Cyprinids	Decrease	IR
NumberCatostomids Species	Decrease	CH, IR
Percent Catostomids	Decrease	CH
Percent Round-Bodied Catostomids	Decrease	CH, IR
Number Sensitive Species	Decrease	CH, IR, RU
Percent Sensitive	Decrease	CH, IR, RU
Percent Tolerant	Increase	CH, IR, RU
Percent Detritivores and Filter-Feeders	Increase	CH, RU
Percent Insectivorous Cyprinids	Decrease	CH, IR, RU
Percent Benthic Insectivores	Decrease	CH
Percent Top Carnivore	Decrease	CH, IR
CPUE	Decrease	CH, IR
Percent Introduced	Increase	RU
Percent Pelagophilous spawners	Decrease	CH, IR
Percent Lithopelagophilous spawners	Decrease	CH
Percent Pelagophils and Lithopelagophils	Decrease	CH
Percent DELT	Increase	RU

Number of Native Cyprinid Species. The number of native cyprinid species represents a diverse family found throughout the entire Missouri River basin. A decline in the number of native cyprinid species generally indicates a lack of habitat diversity (Hughes and Gammon 1987).

This replaces the original IBI metric, the number of sunfish species, which was indicative of degradation of pool habitat. Historically, centrarchids were not uniformly distributed throughout the Missouri River basin (Appendix A) and are more representative of lakes, ponds, and smaller streams (Moyle and Cech 1988).

Table 3. Species collected in the Missouri and lower Yellowstone River that were classified as members of the large river faunal group. Species in **bold** were considered sensitive species.

Family	Scientific Name	Common Name
Acipenseridae	***Scaphirhynchus albus***	**pallid sturgeon**
Acipenseridae	***Scaphirhynchus platorynchus***	**shovelnose sturgeon**
Polyodontidae	*Polyodon spathula*	paddlefish
Lepisosteidae	*Lepisosteus platostomus*	shortnose gar
Hiodontidae	*Hiodon alosoides*	goldeye
Clupeidae	*Alosa chrysochloris*	skipjack herring
Cyprinidae	***Hybognathus argyritis***	**western silvery minnow**
Cyprinidae	***Hybognathus hankinsoni***	**brassy minnow**
Cyprinidae	***Hybognathus placitus***	**plains minnow**
Cyprinidae	***Macrhybopsis aestivalis***	**speckled chub**
Cyprinidae	***Macrhybopsis gelida***	**sturgeon chub**
Cyprinidae	***Macrhybopsis meeki***	**sicklefin chub**
Cyprinidae	*Macrhybopsis storeriana*	silver chub
Cyprinidae	*Notropis atherinoides*	emerald shiner
Cyprinidae	*Notropis blennius*	river shiner
Cyprinidae	*Notropis shumardi*	silverband shiner
Cyprinidae	*Notropis volucellus*	mimic shiner
Cyprinidae	*Platygobio gracilis*	**flathead chub**
Catostomidae	***Cycleptus elongatus***	**blue sucker**
Catostomidae	*Ictiobus bubalus*	smallmouth buffalo
Catostomidae	*Ictiobus cyprinellus*	bigmouth buffalo
Ictaluridae	***Ictalurus furcatus***	**blue catfish**
Gadidae	*Lota lota*	burbot
Percidae	***Sander canadensis***	**sauger**
Sciaenidae	*Aplodinotus grunniens*	freshwater drum

Number of Catostomid Species. Several members of the family Catostomidae are known to be intolerant to habitat and chemical degradation (Karr et al. 1986; Ohio EPA 1987b). Additionally, catostomids are relatively long-lived species and therefore provide a metric that allows a long-term assessment.

Percent Catostomids. This metric has the same rationale as the number of catostomid species. It was changed to a percentage of the total catch to negate stream-size effects.

Percent Round-Bodied Catostomids. The percentage of round-bodied catostomids (genera *Moxostoma*, *Hypentelium*, and *Cycleptus*) reflects changes in run and pool habitat (Simon and Emery 1995). This metric is similar to percent catostomids, but excludes members of the genera *Carpiodes*, *Catostomus*, and *Ictiobus* because of their common occurrence in degraded habitats (Simon and Emery 1995).

Number of Sensitive Species. Species were defined as sensitive if published literature or regional fish keys listed specific intolerances to environmental perturbations that were pertinent to the Missouri River (e.g., channelization, flow regulation). Species were also defined as sensitive if substantial declines in abundance or range have been documented in the Missouri River basin, whether the particular mechanisms responsible for their declines are understood or not. Generally, those species in the latter category have been identified by state natural resource agencies as species of concern. In general, these are species that are the first to decline with increased anthropogenic disturbances. This metric was used in the original IBI (Karr 1981) and has been widely used in most other developed indices (Simon and Lyons 1995; Lyons et al. 2001). For the Missouri River and the lower Yellowstone River, those species identified as sensitive were all members of the large river faunal group (Table 3).

Percent Sensitive Species. This metric has the same rationale as the number of sensitive species. It is changed to a percentage of the total catch to negate the effects of stream size.

Percent Tolerant Species. This metric reflects the dominance of tolerant species. At degraded sites, tolerant species will tend to dominate the total number of individuals (Karr 1981). Originally, percent green sunfish was used because it is a common tolerant species in small midwestern streams (Karr 1981). Variations have included such metrics as the percent *Rhinichthys* species (Steedman 1988), percent white sucker (Miller et al. 1988), percent creek chub (Leonard and Orth 1986), and percent common carp (Hughes and Gammon 1987). The most common variation has been to use the percentage of the total catch that is made up of tolerant species (Lyons et al. 2001). The number of tolerant species has also been used (Simon and Emery 1995), but does not reflect the original intention of demonstrating numerical dominance and therefore was not considered here. A total of 22 species classified as tolerant were collected on the Missouri River and lower Yellowstone River during this study (Table 4).

Percent Detritivores and Filter-Feeding Herbivores and Planktivores. This metric is indicative of a degraded food base, especially aquatic insects, algae, and aquatic macrophytes. Detritivores are plastic in their diets whereas filter-feeding species would benefit from the effects of channelization and lentic habitat created by reservoirs. We focused on the mode of feeding more than the actual food items consumed because of large discrepancies in descriptions of the feeding ecology of many species found in the Missouri River (Goldstein and Simon 1999). Whereas this metric has been called percent omnivores, percent opportunist feeders, and percent generalists, it is generally meant to reflect species that show a large degree of plasticity in their feeding habits.

These metrics are ecologically sound, but feeding information for many species was contradictory and therefore we could not accurately place these species into these feeding habits with any certainty. A total of nine species were classified as a detritivore, a filter-feeding herbivore, or a filter-feeding planktivore (Table 5).

Percent Insectivorous Cyprinids. The relative abundance of insectivorous cyprinids has been shown to decrease with increased degradation in Midwestern streams (Karr et al. 1986) and was used in the original IBI (Karr 1981). This metric has been modified to the percent of specialized insectivores (e.g., Ohio EPA 1987b) and the percent of insectivores (e.g., Simon and Emery 1995; Emery et al. 2003). Because cyprinids are common throughout the entire Missouri River, inclusion of non-cyprinids in this metric was unnecessary. Twenty-six of the 36 cyprinid species collected from the Missouri River and lower Yellowstone River were classified as insectivorous as adults (Table 6).

Table 4. Species collected in the Missouri and lower Yellowstone River that were classified as tolerant species.

Family	Scientific Name	Common Name
Lepisosteidae	*Lepisosteus osseus*	longnose gar
Amiidae	*Amia calva*	bowfin
Hiodontidae	*Hiodon alosoides*	goldeye
Clupeidae	*Dorosoma cepedianum*	gizzard shad
Cyprinidae	*Carassius auratus*	goldfish
Cyprinidae	*Ctenopharyngodon idella*	grass carp
Cyprinidae	*Cyprinella lutrensis*	red shiner
Cyprinidae	*Cyprinella spiloptera*	spotfin shiner
Cyprinidae	*Cyprinus carpio*	common carp
Cyprinidae	*Hypophthalmichthys nobilis*	bighead carp
Cyprinidae	*Notemigonus crysoleucas*	golden shiner
Cyprinidae	*Pimephales notatus*	bluntnose minnow
Cyprinidae	*Pimephales promelas*	fathead minnow
Cyprinidae	*Semotilus atromaculatus*	creek chub
Catostomidae	*Catostomus commersoni*	white sucker
Catostomidae	*Ictiobus bubalus*	smallmouth buffalo
Catostomidae	*Ictiobus cyprinellus*	bigmouth buffalo
Ictaluridae	*Ameiurus melas*	black bullhead
Percichthyidae	*Morone chrysops*	white bass
Centrarchidae	*Lepomis cyanellus*	green sunfish
Centrarchidae	*Lepomis humilis*	orangespotted sunfish
Centrarchidae	*Lepomis macrochirus*	bluegill

Percent Benthic Insectivores. This metric was meant to be similar to the percent of insectivorous cyprinids metric, but included members of other families and excluded species that fed from the water column (Table 7). This metric should be more sensitive to perturbations specific to the Missouri River because it focused on benthic species. We hypothesized that the food-base for benthic insectivorous fish would be more susceptible to the impacts associated with channel and alterations in the Missouri River (i.e., impoundment, channelization, dredging).

Table 5. Species collected in the Missouri and lower Yellowstone River that were classified as detritivores, filter-feeding herbivores, or filter-feeding planktivores.

Family	Scientific Name	Common Name
Petromyzontidae	*Ichthyomyzon castaneus*	chestnut lamprey (ammocoete)
Polydontidae	*Polydon spathula*	paddlefish
Clupeidae	*Alosa chrysochloris*	skipjack herring
Clupeidae	*Dorosoma cepedianum*	gizzard shad
Clupeidae	*Dorosoma petenense*	threadfin shad
Cyprinidae	*Pimephales notatus*	bluntnose minnow
Cyprinidae	*Pimephales promelas*	fathead minnow
Catostomidae	*Carpiodes carpio*	river carpsucker
Catostomidae	*Carpiodes velifer*	highfin carpsucker

Percent Top Carnivores. This metric includes all species which, as adults, are mainly piscivorous or feed on large prey items such as crayfish or amphibians (Karr et al. 1986). Whereas generally not comprising a large proportion of the relative abundance of the fish assemblage, a stable, healthy population of these species indicates a well-balanced aquatic community (Karr et al. 1986). A total of eight species collected in the Missouri River and lower Yellowstone River were classified as top carnivores (Table 8).

Catch Per Unit Effort (CPUE). This metric is based on the premise that total numbers of individuals will be lower at degraded sites. This metric has been used in most indices developed to date and has been shown to be responsive to anthropogenic stress, except in some situations where increases in the abundance of tolerant species have masked the effect (Simon and Lyons 1995).

Catch per unit effort was calculated by dividing the total number of native individual captured by the total distance sampled. Total distance was the summation of all gears deployed in all main channel habitats.

Percent Introduced Individuals. The percentage of the total catch that is made up of introduced or exotic species is indicative of the degree to which native species have been replaced or the degree to which habitat degradation or modification favors introduced species. Alternately, this metric may not directly indicate habitat or water quality degradation, but it acknowledges the fact that non-native species are themselves a form of environmental perturbation. The native distribution of each species was based on several regional fish keys, general fish keys, and published manuscripts. Distributions were classified at the segment level (Appendix A).

This metric, or a closely related metric, has often been used to replace the original percent of total catch made up of hybrids metric (e.g., Hughes and Gammon 1987; Crumby et al. 1990; Bramblett and Fausch 1991). The original hybrid metric was meant to indicate the degree of habitat degradation that reduces reproductive isolation among species (Karr et al. 1986).

Percent Pelagophilous spawners. Pelagophil spawners have buoyant eggs that are carried in the water column until the eggs hatch (Simon 1999b). We hypothesized that fish exhibiting this type of reproductive behavior would demonstrate declines in the inter-reservoir zone because eggs would not have sufficient length of free-flowing river to develop before they were in lentic reservoir environments. Some discrepancy exists in the literature whether *Hybognathus* species and *Macrhybopsis* species exhibit this type of reproductive behavior or if they are lithopelagophilous spawners (Johnson and Page 1992; Platania and Altenback 1998; Simon 1999b). These species were classified as pelagophil spawners for data analysis (Table 9).

Table 6. Cyprinid species collected in the Missouri and lower Yellowstone River that were classified as insectivores.

Scientific Name	Common Name
Carassius auratus	goldfish
Couesius plumbeus	lake chub
Cypinella lutrensis	red shiner
Cyprinella spiloptera	spotfin shiner
Cyprinus carpio	common carp
Hypophthalmichthys nobilis	bighead carp
Luxilus chrysocephalus	striped shiner
Luxilus cornutus	common shiner
Macrhybopsis aestivalis	speckled chub
Macrhybopsis gelida	sturgeon chub
Macrhybopsis meeki	sicklefin chub
Margariscus margarita	pearl dace
Notemigonus crysoleucas	golden shiner
Notropis blennius	river shiner
Notropis boops	bigeye shiner
Notropis buchanani	ghost shiner
Notropis dorsalis	bigmouth shiner
Notropis hudsonius	spottail shiner
Notropis shumardi	silverband shiner
Notropis stramineus	sand shiner
Notropis volucellus	mimic shiner
Phenacobius mirabilis	suckermouth minnow
Phoxinus eos	northern redbelly dace
Platygobio gracilis	flathead chub
Rhinichthys cataractae	longnose dace
Semotilus atromaculatus	creek chub

Table 7. Species collected in the Missouri and lower Yellowstone River that were classified as benthic insectivores.

Family	Scientific Name	Common Name
Acipenseridae	*Scaphirhynchus platorynchus*	shovelnose sturgeon
Cyprinidae	*Carassius auratus*	goldfish
Cyprinidae	*Cypinella lutrensis*	red shiner
Cyprinidae	*Cyprinus carpio*	common carp
Cyprinidae	*Macrhybopsis aestivalis*	speckled chub
Cyprinidae	*Macrhybopsis gelida*	sturgeon chub
Cyprinidae	*Macrhybopsis meeki*	sicklefin chub
Cyprinidae	*Notropis dorsalis*	bigmouth shiner
Cyprinidae	*Notropis stramineus*	sand shiner
Cyprinidae	*Phenacobius mirabilis*	suckermouth minnow
Cyprinidae	*Rhinichthys cataractae*	longnose dace
Catostomidae	*Carpiodes cyprinus*	quillback
Catostomidae	*Catostomus catostomus*	longnose sucker
Catostomidae	*Catostomus commersoni*	white sucker
Catostomidae	*Cycleptus elongatus*	blue sucker
Catostomidae	*Hypentelium nigricans*	northern hog sucker
Catostomidae	*Ictiobus bubalus*	smallmouth buffalo
Catostomidae	*Moxostoma carinatum*	river redhorse
Catostomidae	*Moxostoma erythrurum*	golden redhorse
Catostomidae	*Moxostoma macrolepidotum*	shorthead redhorse
Ictaluridae	*Noturus exilis*	slender madtom
Ictaluridae	*Noturus gyrinus*	tadpole madtom
Ictaluridae	*Noturus nocturnus*	freckled madtom
Cottidae	*Cottus bairdi*	mottled sculpin
Percidae	*Etheostoma nigrum*	johnny darter
Percidae	*Percina caprodes*	logperch

Table 8. Species collected in the Missouri and lower Yellowstone River that were classified as top carnivores.

Family	Scientific Name	Common Name
Lepisosteidae	*Lepisosteus oculatus*	spotted gar
Lepisosteidae	*Lepisosteus osseus*	longnose gar
Lepisosteidae	*Lepisosteus platostomus*	shortnose gar
Amiidae	*Amia calva*	bowfin
Esocidae	*Esox lucius*	northern pike
Esocidae	*Esox masquinongy*	muskellunge
Percidae	*Sander canadensis*	sauger
Percidae	*Sander vitreus*	walleye

Percent Lithopelagophilous spawners. Another method of reproduction that we hypothesized could show declines in the inter-reservoir zone of the Missouri River was percent of lithopelagophilous spawners. Lithopelagophilous spawners have buoyant, free-floating larvae that are carried in the water column (Simon 1999b). We hypothesized that this reproductive form would also be hampered by the lentic habitat created by reservoirs. This reproductive form was fairly common as 27 species collected on the Missouri River and lower Yellowstone River were classified as lithopelagophilous spawners (Table 10).

Percent Pelagophilous and Lithopelagophilous spawners. This metric was the combination of the two previous types of spawners. This metric would reflect declines in all species that require long sections of free-flowing river for either eggs or larvae to develop. This metric was included in order to alleviate the problems associated with discrepancies in the reproductive strategies of *Hybognathus* species and *Macrhybopsis* species which may be either pelagophilous or lithopelagophilous spawners.

Percent Deformities, Erosions, Lesions, and Tumors (DELT). The percentage of individuals with external, easily observable deformities, eroding fins, lesions, and tumors (commonly referred to as the DELT metric) was one of the original metrics used (Karr 1981) and has been widely used in many other indices (Simon and Lyons 1995; Hughes and Oberdorff 1999). Parasites and parasitic diseases were not included in this metric because there has been little correlation found between the presence of parasites and stream quality (Whittier et al. 1987; Steedman 1988; Simon and Emery 1995). This metric has been shown to be sensitive to industrial and sewage discharges (Sanders et al. 1999).

Metric Responsiveness

Data from all sites on the Missouri and Yellowstone rivers were analyzed to determine if each metric could discriminate between the reference sites (least-altered) and impacted sites (inter-reservoir, regulated-unchannelized, and channelized). The non-parametric Kruskal-Wallis One-Way ANOVA test on ranks was used (Zar 1999). If the test was significant ($p < 0.05$), the Kruskal-Wallis multiple comparison Z-value test was conducted to determine which zones differed significantly from other zones. Nonparametric procedures were used because of the non-normal distribution of many of the metrics.

Metric Redundancy

The degree to which metrics were redundant to one another was analyzed using the nonparametric Spearman correlation test. This test is analogous to the parametric Pearson correlation, but the analysis is performed on the ranks of the data. This nonparametric procedure was used because of the non-normal distribution of many of the metrics. An $r^2 = 0.50$ was used as the cutoff to test for significant correlations. A Bonferroni correction was used to determine

Table 9. Species collected in the Missouri and lower Yellowstone River that were classified as pelagophilous spawners. Asterisks indicate species where discrepancies or uncertainties exist in reproductive guild. These fish are potentially lithopelagophilous spawners.

Family	Scientific Name	Common Name
Hiodontidae	*Hiodon alosoides*	goldeye
Cyprinidae	*Ctenopharyngodon idella*	grass carp
Cyprinidae	*Hybognathus argyritis*	western silvery minnow*
Cyprinidae	*Hybognathus hankinsoni*	brassy minnow*
Cyprinidae	*Hybognathus placitus*	plains minnow*
Cyprinidae	*Hypophthalmichthys nobilis*	bighead carp
Cyprinidae	*Macrhybopsis aestivalis*	speckled chub*
Cyprinidae	*Macrhybopsis gelida*	sturgeon chub*
Cyprinidae	*Macrhybopsis meeki*	sicklefin chub*
Cyprinidae	*Macrhybopsis storeriana*	silver chub*
Cyprinidae	*Notropis atherinoides*	emerald shiner
Cyprinidae	*Notropis dorsalis*	bigmouth shiner
Salmonidae	*Coregonus artedi*	cisco
Scianidae	*Aplodinotus grunniens*	freshwater drum

significance (0.05/number of pairwise comparisons).

Metric Variability

Metric variability was evaluated by examining the coefficients of variation (CV; 100 x SD/Mean) for the data from the reference sites only. High variability in the reference site data would suggest that the metric was too variable to be of much use in the index (Mebane et al. 2003) while high variability in degraded sites may actually reflect degraded conditions (Fore et al. 1994). Barbour et al. (1996) suggested a metric with a CV greater than 100% usually is rejected. However, if this occurs with metrics that generally have very low values (i.e., near zero) then the analysis should be conducted on the metric scores instead of the raw data (Mebane et al. 2003). The CV was measured for both the raw data and the metric scores for all metrics.

Metric Scoring and Index Construction

Standardized metrics were scored continuously from 0 to 1 (Minns et al. 1994; Hughes et al. 1998; McCormick et al. 2001; Mebane et al. 2003). Metrics were then scaled as necessary to create an IBI where scores varied from 0 to 100.

Maximum scores for each candidate metric were evaluated using data from only the segments in the least-altered zone to determine the reference condition. In general, the 75th percentile of the reference site data was then set as the best reference condition (but see below for deviations), which corresponded to a score of 1 (i.e., best possible score for that individual metric). The range of data at all sites was then examined to determine where the minimum score of 0 should occur (i.e., lowest possible score for that individual metric).

Metric Contribution to Index Score

The sensitivity of the index to individual metrics was examined by calculating a reduced index (Mebane et al. 2003). Metrics were removed sequentially and then the percent difference between the full index and

Table 10. Species collected in the Missouri and lower Yellowstone River that were classified as lithopelagophilous spawners.

Family	Scientific Name	Common Name
Acipenseridae	*Scaphirhynchus albus*	pallid sturgeon
Acipenseridae	*Scaphirhynchus platorynchus*	shovelnose sturgeon
Polyodontidae	*Polyodon spathula*	paddlefish
Clupeidae	*Dorosoma cepedianum*	gizzard shad
Cyprinidae	*Couesius plumbeus*	lake chub
Cyprinidae	*Notropis blennius*	river shiner
Cyprinidae	*Notropis buchanani*	ghost shiner
Cyprinidae	*Notropis hudsonius*	spottail shiner
Cyprinidae	*Notropis shumardi*	silverband shiner
Cyprinidae	*Notropis stramineus*	sand shiner
Cyprinidae	*Phenacobius mirabilis*	suckermouth minnow
Cyprinidae	*Platygobio gracilis*	flathead chub
Cyprinidae	*Rhinichthys cataractae*	longnose dace
Catostomidae	*Carpiodes carpio*	river carpsucker
Catostomidae	*Carpiodes cyprinus*	quillback
Catostomidae	*Carpiodes velifer*	highfin carpsucker
Catostomidae	*Catostomus catostomus*	longnose sucker
Catostomidae	*Catostomus commersoni*	white sucker
Catostomidae	*Cycleptus elongatus*	blue sucker
Catostomidae	*Ictiobus bubalus*	smallmouth buffalo
Catostomidae	*Ictiobus cyprinellus*	bigmouth buffalo
Catostomidae	*Ictiobus niger*	black buffalo
Osmeridae	*Osmerus mordax*	rainbow smelt
Salmonidae	*Coregonus clupeaformis*	lake whitefish
Gadidae	*Lota lota*	burbot
Percidae	*Sander canadensis*	sauger
Percidae	*Sander vitreus*	walleye

the reduced index was calculated to determine the relative contribution of that metric. Total IBI scores were recalculated by adding additional data from discrete macrohabitat sampling to the data set.

RESULTS AND DISCUSSION

Metric Responsiveness

Metrics varied in their ability to discriminate between the least-altered and the inter-reservoir, regulated-unchannelized, and channelized zones. Five of the 19 metrics examined discriminated between the reference sites and the three other river zones in the expected direction (Table 2). The percent large river faunal group (Figure 2), number of sensitive species (Figure 3), percent sensitive species (Figure 4), and percent insectivorous cyprinids (Figure 5) were all significantly higher in the reference sites than the other three river zones, whereas the percent tolerant species (Figure 6) was significantly lower at the reference sites than the other three river zones ($p < 0.05$ for all).

Six of the 19 metrics examined discriminated between the reference sites and two of the other river zones in the expected direction (Table 2). The number of catostomid species (Figure 7), percent round-bodied catostomids (Figure 8), percent top-carnivores (Figure 9), CPUE (Figure 10), and percent pelagophilous spawners (Figure 11) were significantly higher at the reference sites than the channelized and inter-reservoir zones ($P < 0.05$ for all). The percent detritivores and filter-feeding herbivores and planktivores (Figure 12) was significantly lower at the reference sites than the channelized and regulated-unchannelized zones ($p < 0.05$), but not the inter-reservoir zone.

The remaining eight metrics discriminated between the reference sites and one of the other river zones in the expected direction. The percent catostomids (Figure 13), percent benthic insectivores (Figure 14), the percent lithopelagophilous spawners (Figure 15), and percent pelagophilous plus lithopelagophilous spawners (Figure 16) were all significantly higher at the reference sites than the channelized zone ($p < 0.05$), but not the other two zones. The total number of native species (Figure 17) and the total number of native cyprinid species (Figure 18) were all significantly higher at the reference sites than the inter-reservoir zone, but not the other two zones. The percent introduced species (Figure 19) and the % DELT (Figure 20) metrics were both significantly lower at the references sites than the regulated-unchannelized zone, but not the other two zones.

Examination of species richness metrics showed that the total number of native taxa (Figure 21) and the total number of native cyprinid taxa (Figure 22) had a significantly positive slope moving in a downstream direction ($p < 0.01$ for both). This is not surprising because measures of species richness generally increase in a downstream direction. The other species-richness metrics, number of catostomid species (Figure 23) and number of sensitive species (Figure 24), did not show such an increasing trend in a downstream direction and actually had significant negative slopes associated with them ($p < 0.01$ for both).

Metric Redundancy

Few metrics exhibited a large degree of redundancy with one another. Only four comparisons had r^2 values over 0.50. The number of native species was somewhat redundant with the number of native cyprinids ($r^2 = 0.68$, $p < 0.01$) and CPUE ($r^2 = 0.62$, $p < 0.01$). The percentage of individuals of the large-river faunal group was weakly correlated with the percentage of individuals as sensitive species ($r^2 = 0.51$, $p < 0.01$) and the percentage of pelagophilous and lithopelagophilous spawners ($r^2 = 0.50$, $p < 0.01$).

Metric Variability

The CV exceeded 100% for only three candidate metrics. The percent catostomids metric had a CV of 116% while the percent round-bodied catostomids metric had a CV of 137% and the percent DELT metric had the highest CV at 288%. However, the percent round-bodied catostomids and percent DELT metrics consistently had values near zero, making them susceptible to high CVs. This was not the case for the percent catostomids metric values, for which the elevated CV was probably representative of actual variation in the data.

Metric Scoring and Index Construction

Examination of metric responsiveness, redundancy and variability did not indicate that any particular metric was completely unsuitable for inclusion in a final IBI. All metrics were initially carried forward for scoring. Scored metrics were then reexamined for redundancy and variability.

Most metrics did not show a relationship with stream size and did not need to be scored using linear equations (Table 11). Two metrics did vary with stream size. Linear equations were developed for both the number of species and the number of cyprinid species based on site location (rkm) to predict the number of species required to receive a maximum score. For total number of native species, the "maximum species richness" value is calculated by the equation:

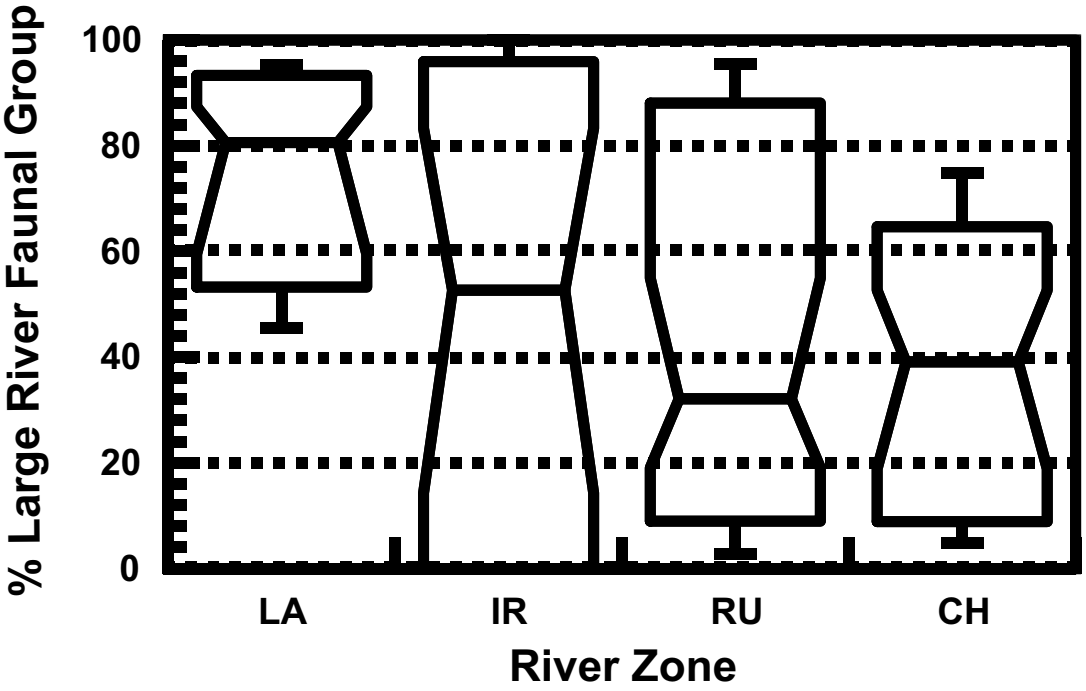

Figure 2. Box plot of the percent of individuals made up of members of the large river faunal group by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

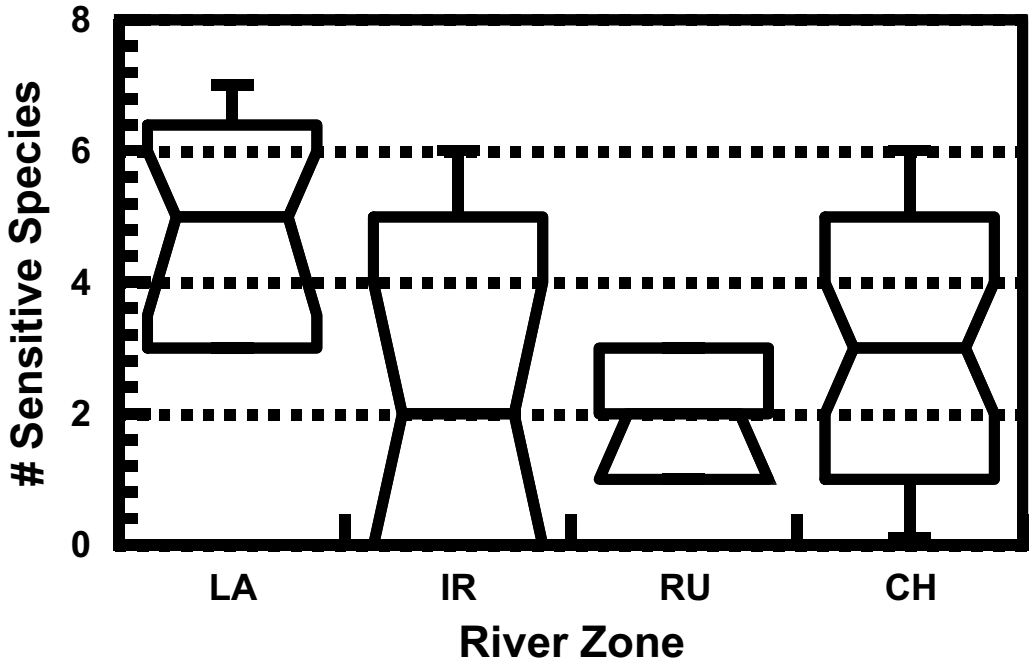

Figure 3. Box plot of the number of sensitive species by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

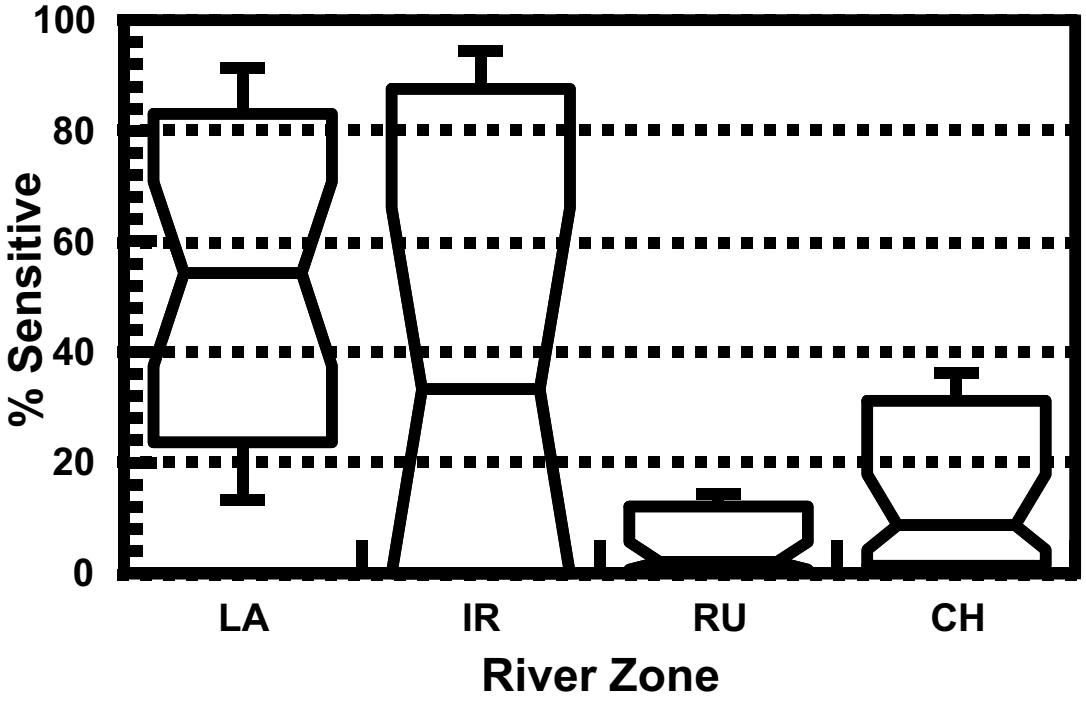

Figure 4. Box plot of the percent of individuals made up of sensitive species by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

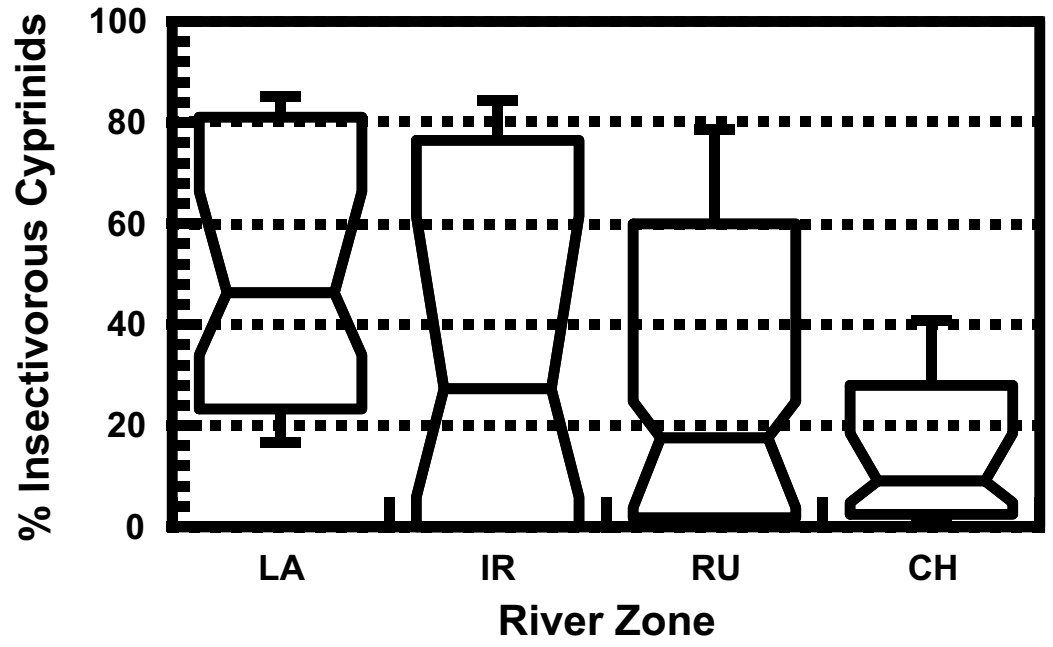

Figure 5. Box plot of the percent of individuals made up of insectivorous cyprinids by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

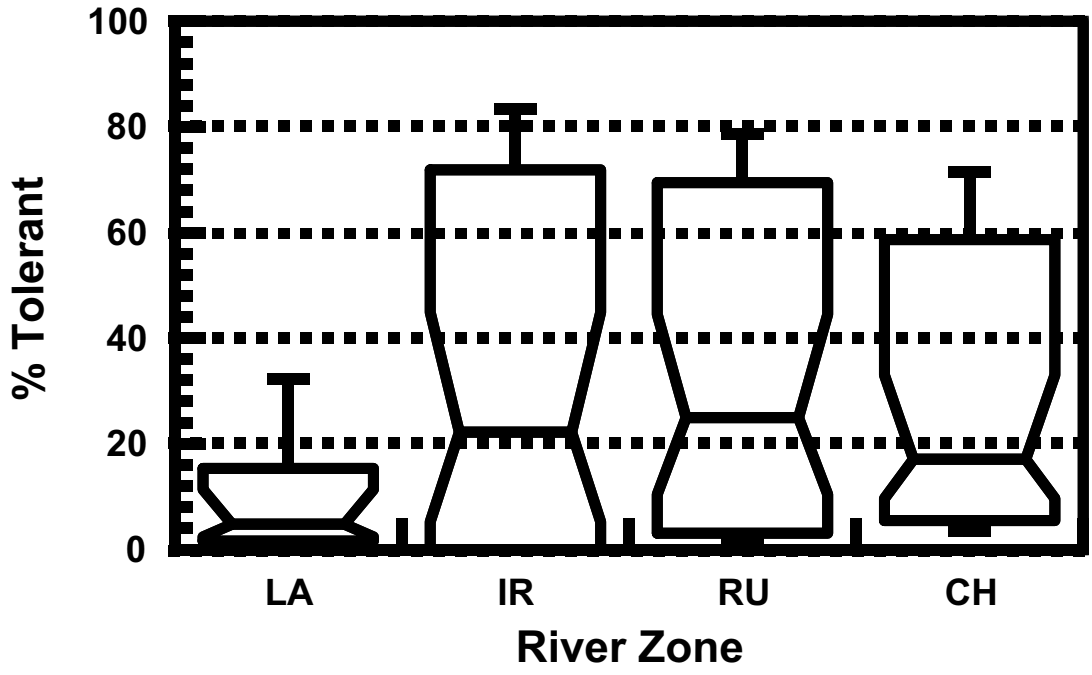

Figure 6. Box plot of the percent of individuals made up of tolerant species by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

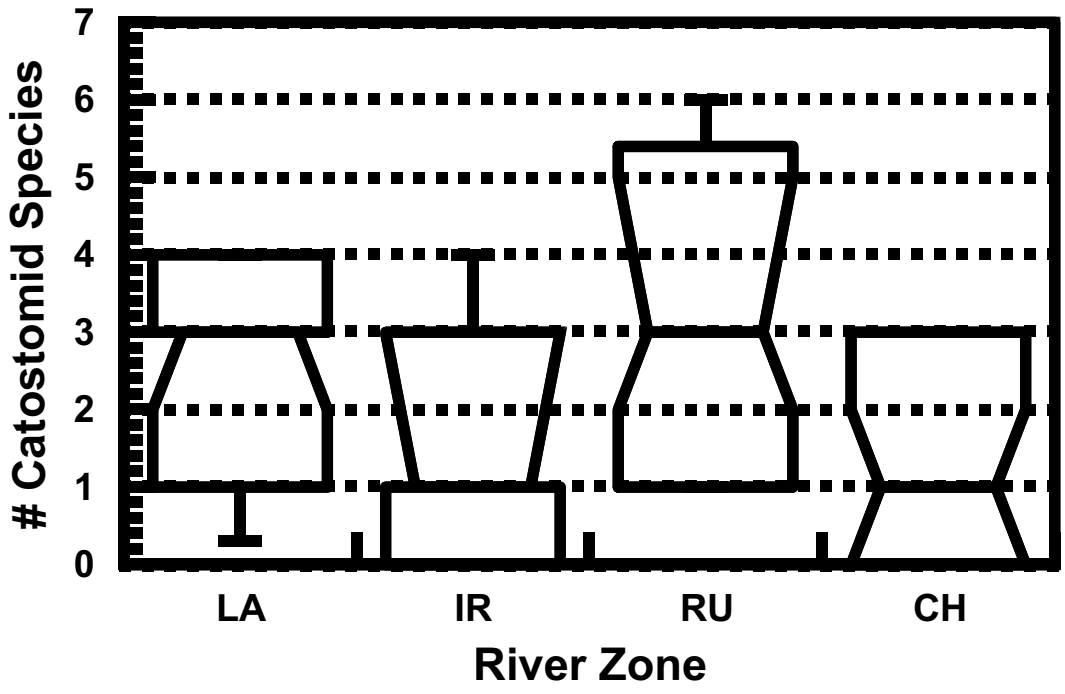

Figure 7. Box plot of the number of catostomid species by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

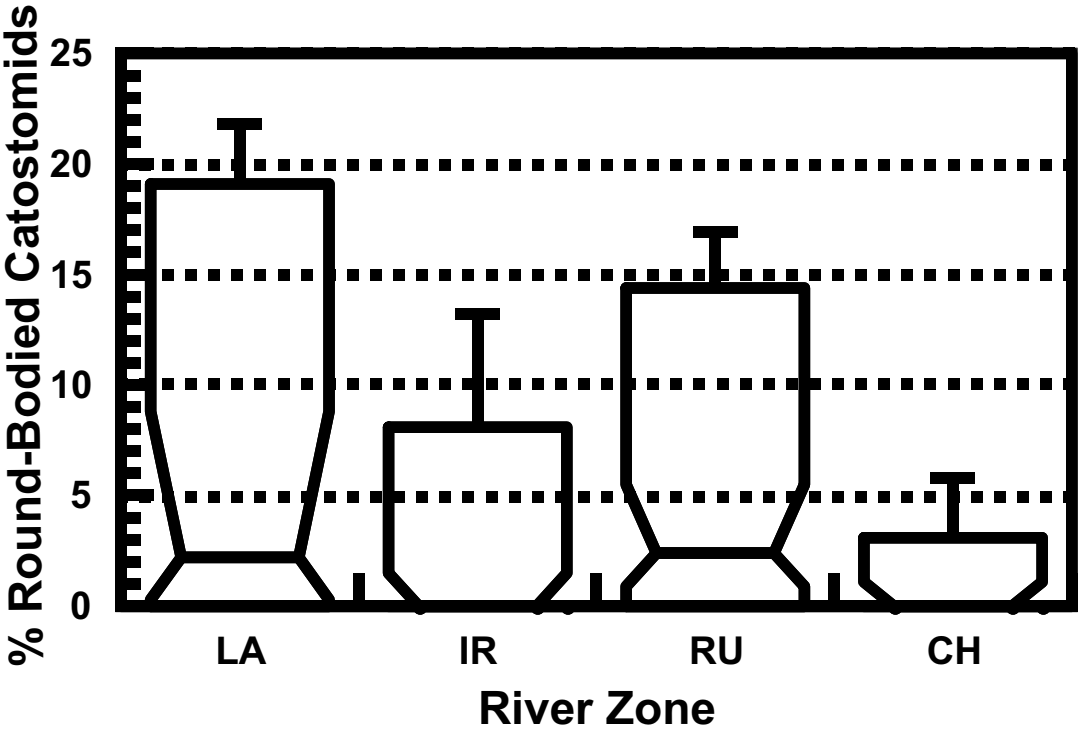

Figure 8. Box plot of the percent of individuals made up of round-bodied catostomids by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

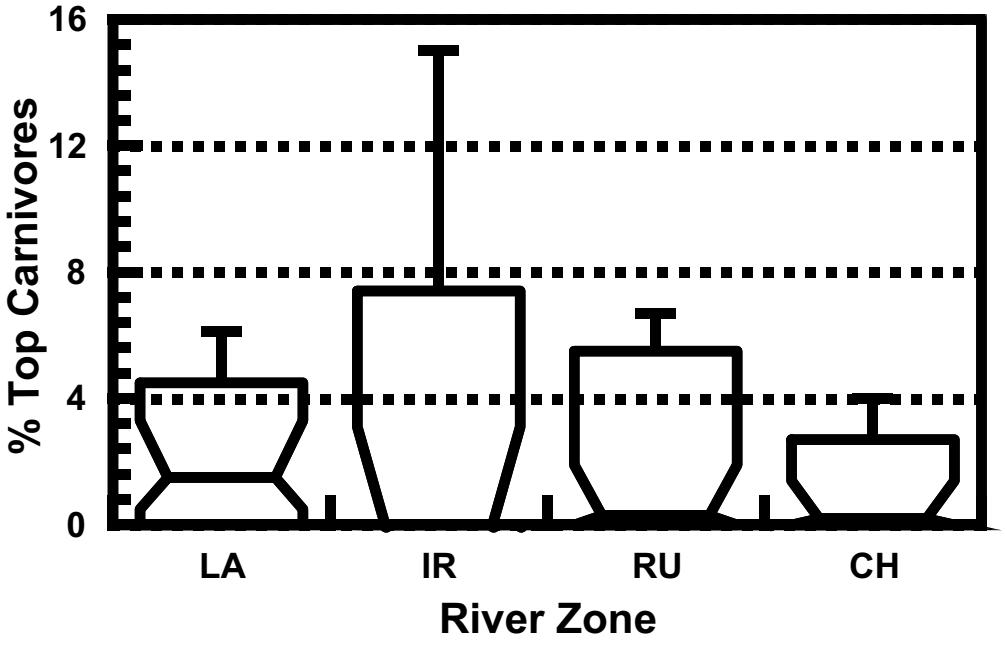

Figure 9. Box plot of the percent of individuals made up of top carnivores by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

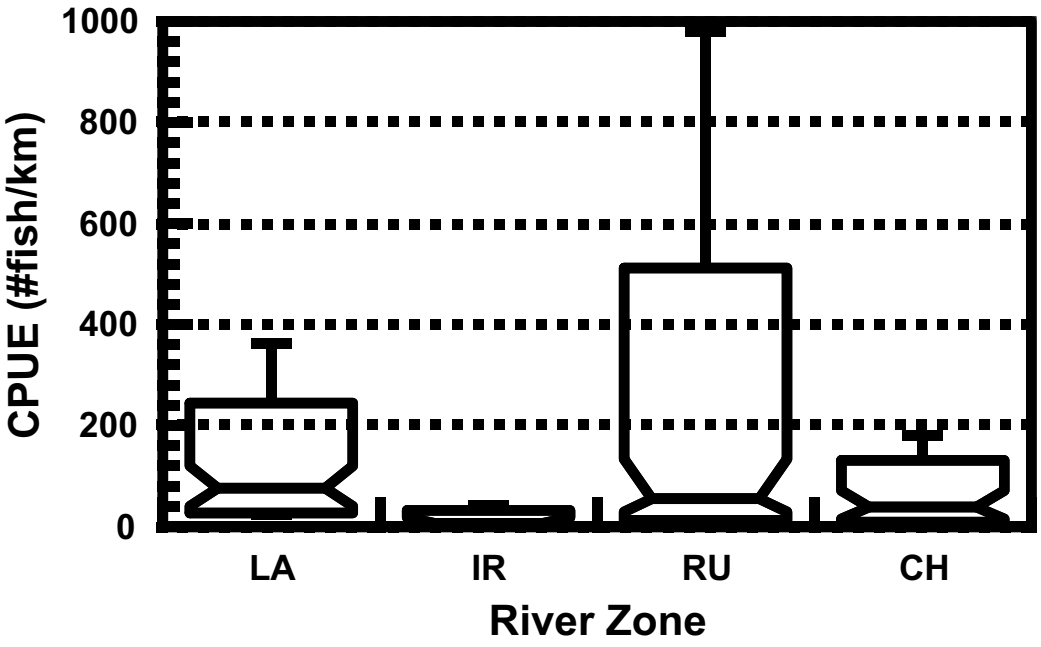

Figure 10. Box plot of catch per unit effort (fish/km) by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

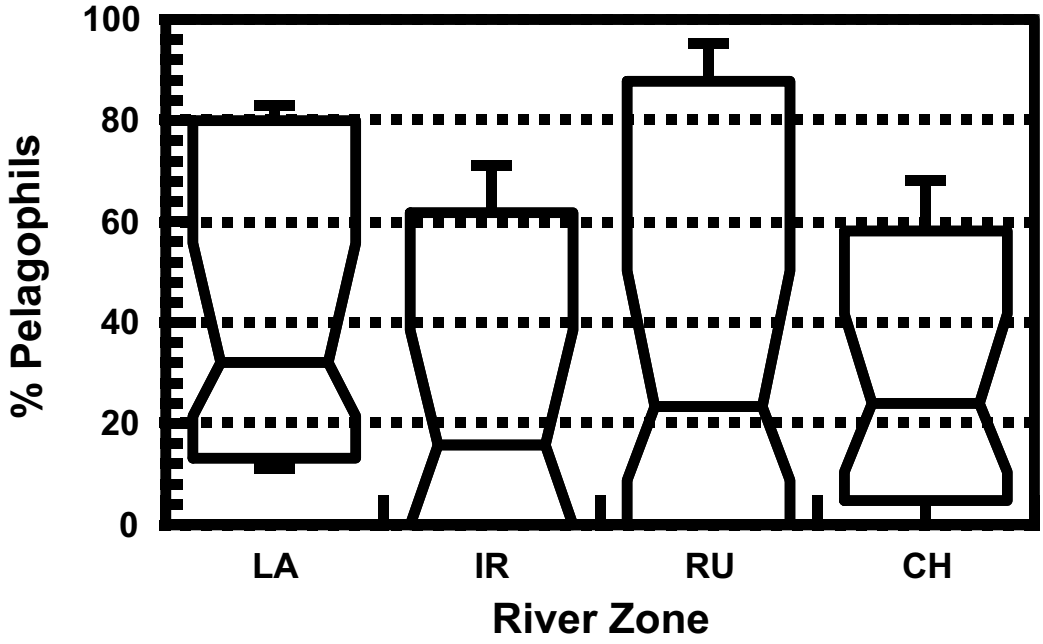

Figure 11. Box plot of the percent of individuals made up of pelagophilous spawners by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

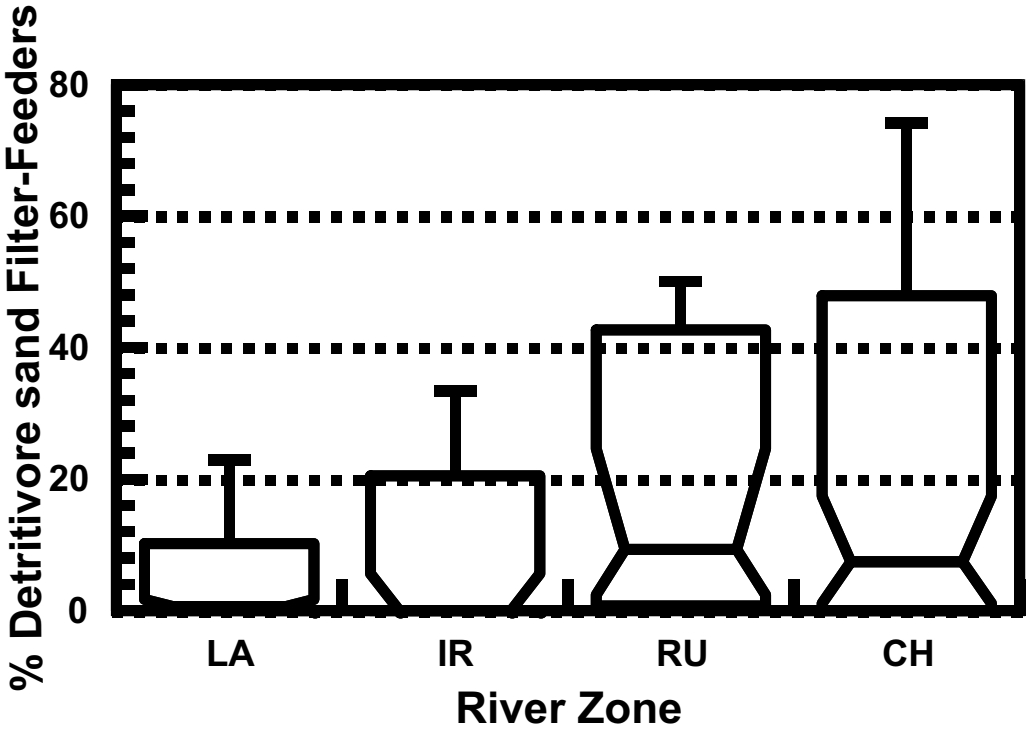

Figure 12. Box plot of the percent of individuals made up of detritivores, filter-feeding herbivores, and filter-feeding planktivores by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

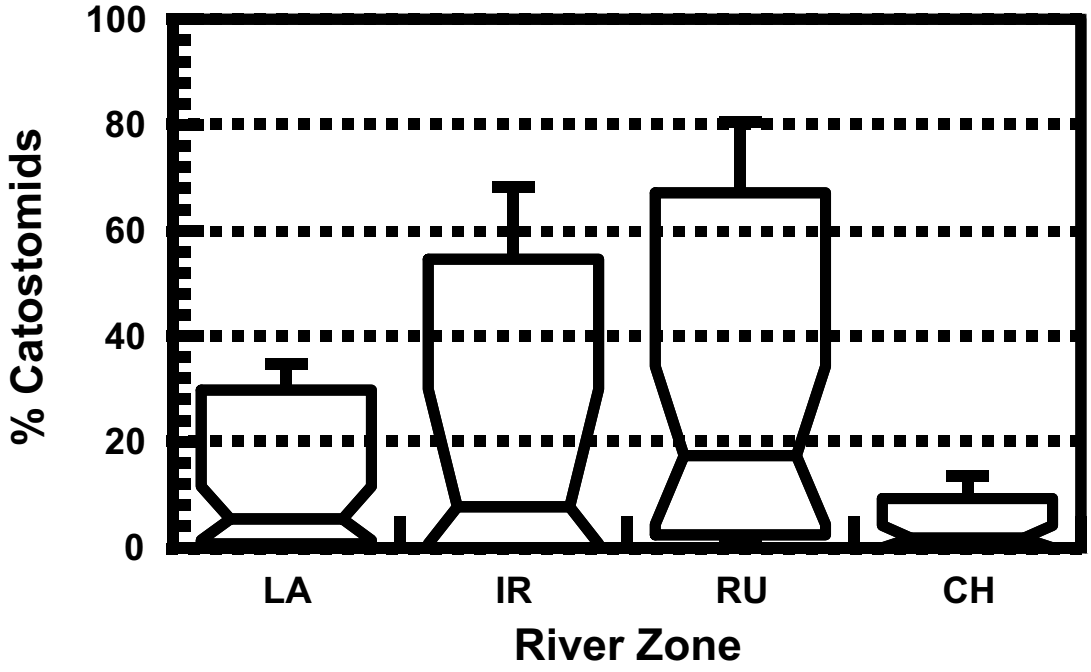

Figure 13. Box plot of the percent of individuals made up of catostomid species by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

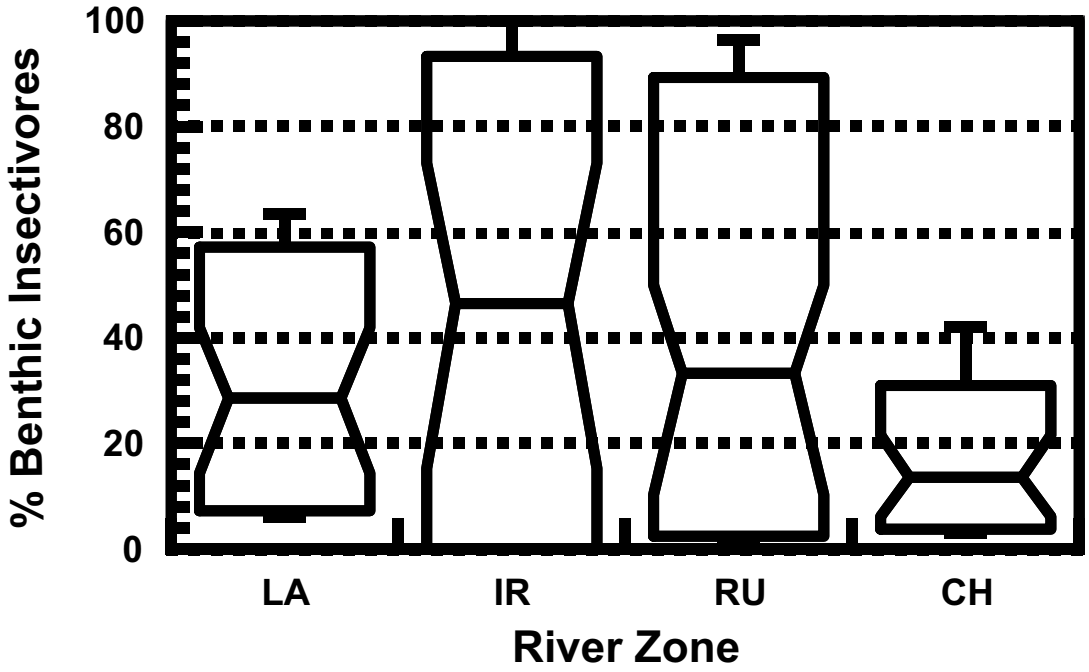

Figure 14. Box plot of the percent of individuals made up of benthic insectivores by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

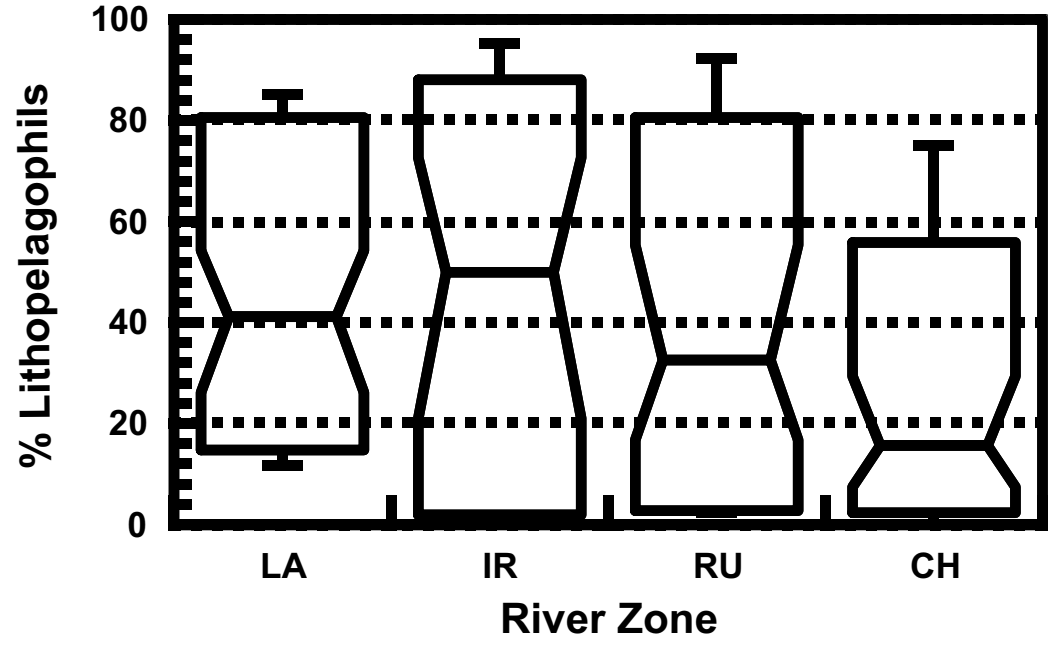

Figure 15. Box plot of the percent of individuals made up of lithopelagophilous spawners by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

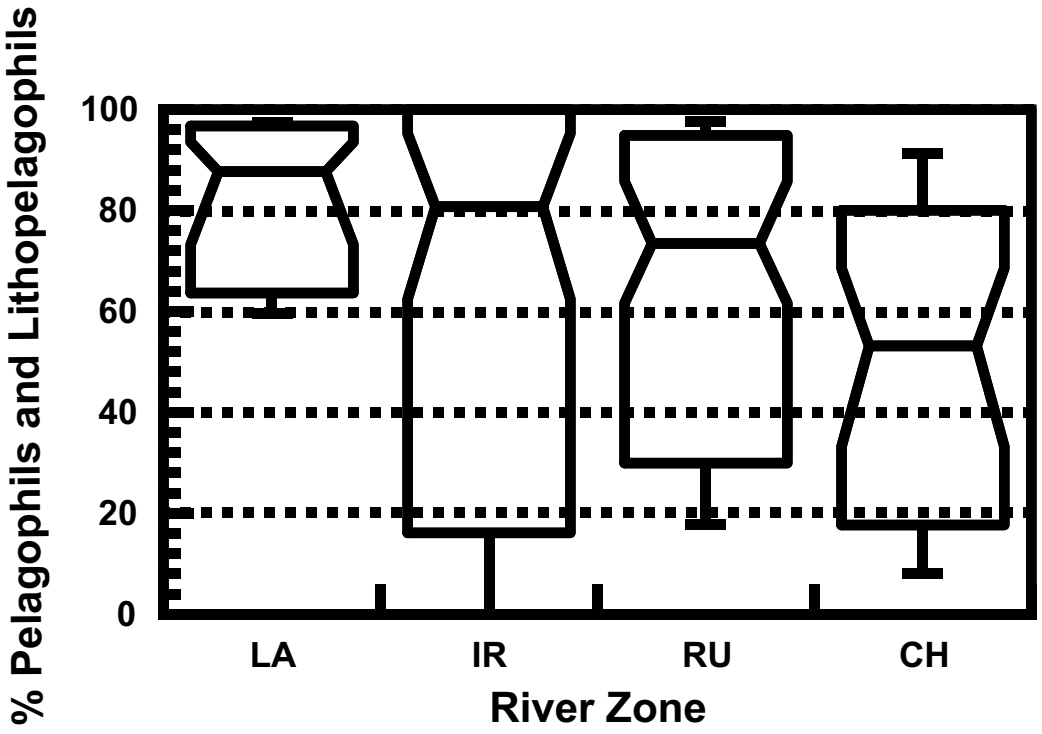

Figure 16. Box plot of the percent of individuals made up of lithopelagophilous and pelagophilous spawners by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

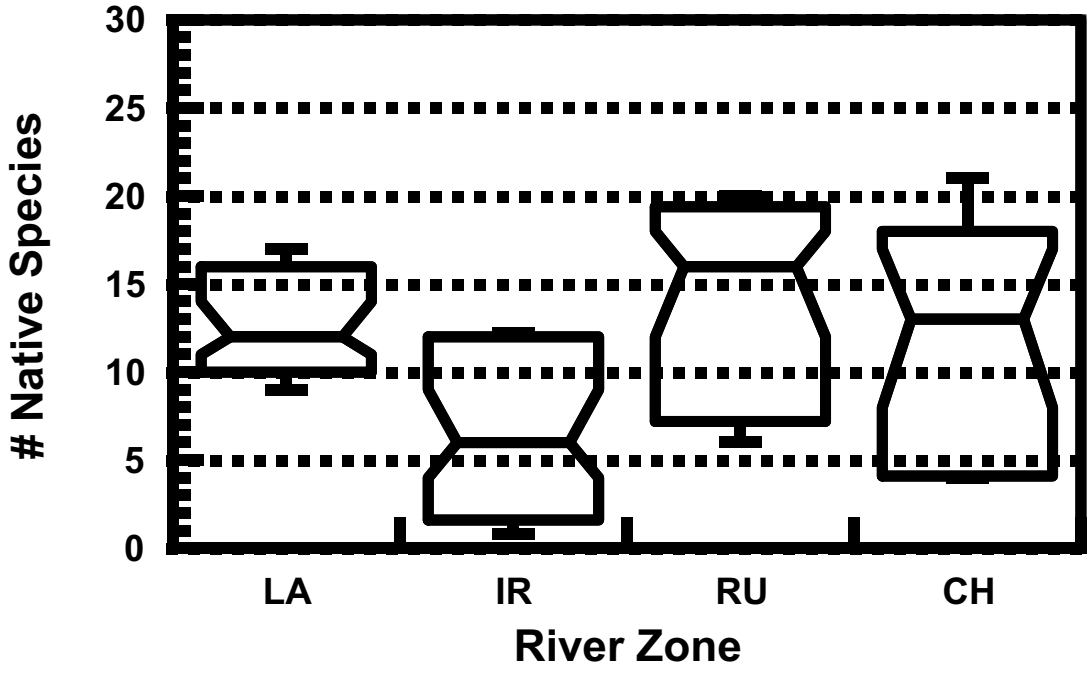

Figure 17. Box plot of the number of native species by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

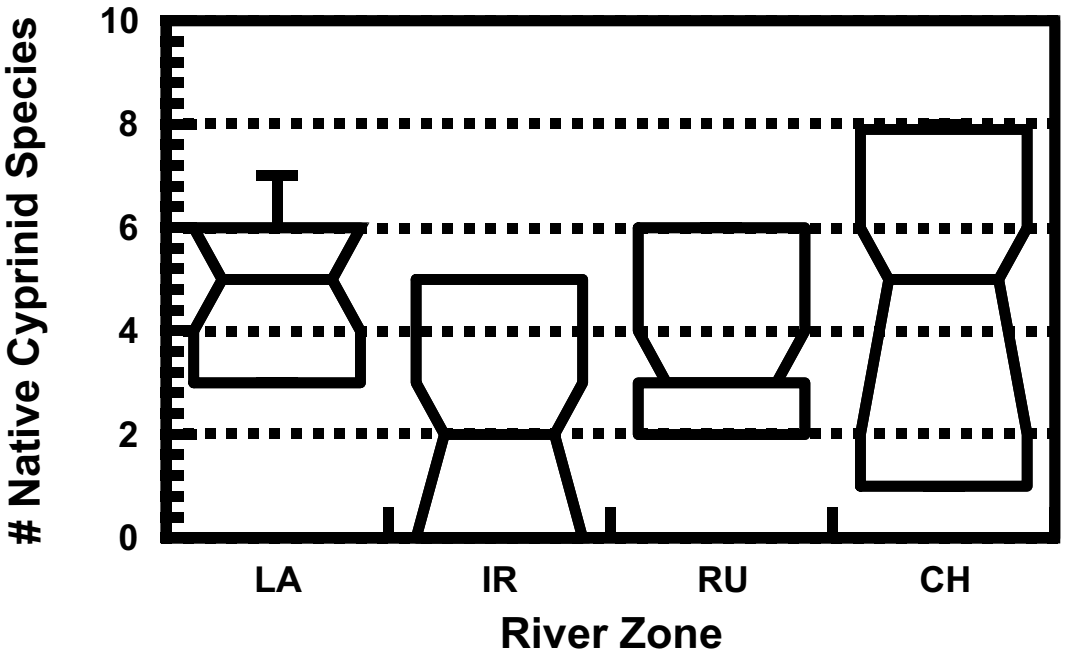

Figure 18. Box plot of the number of native cyprinid species by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

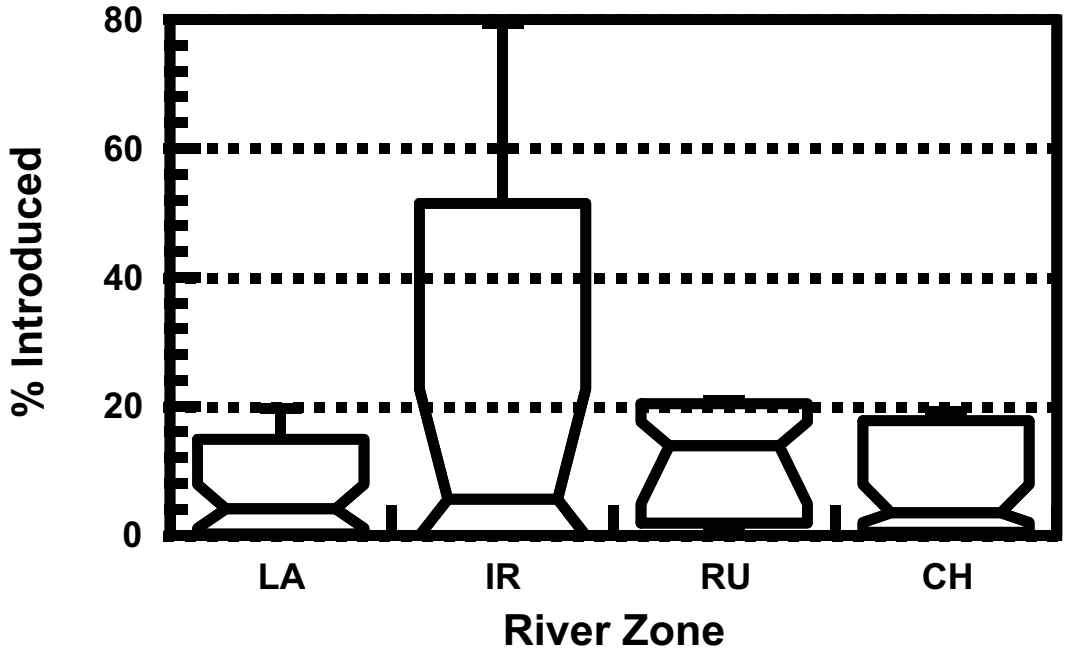

Figure 19. Box plot of the percent of individuals made up of introduced species by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

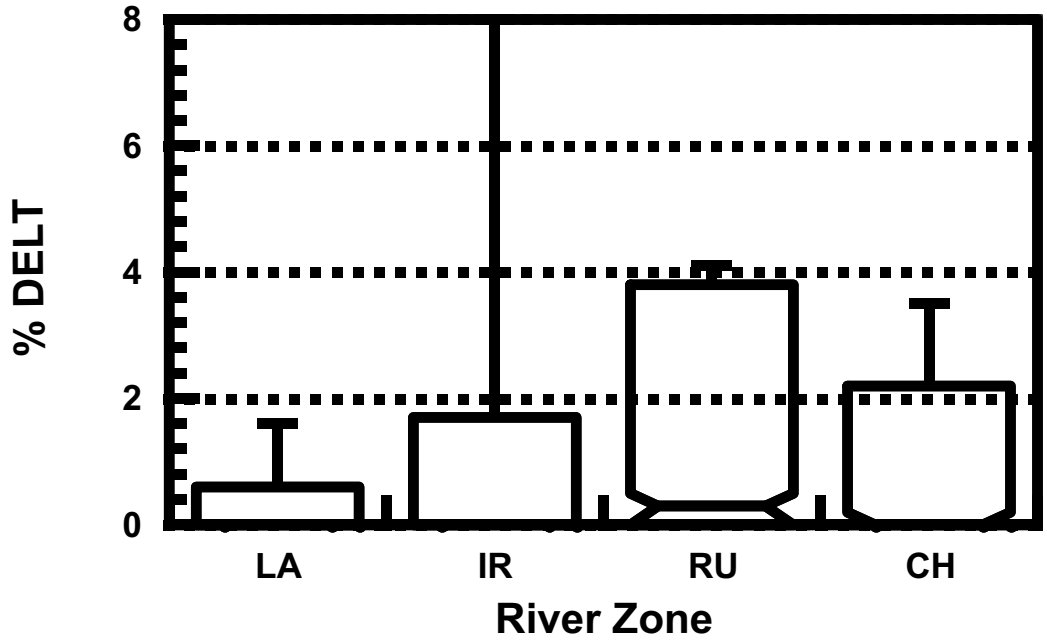

Figure 20. Box plot of the percent of individuals with deformities, erosion, lesions, or tumors by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

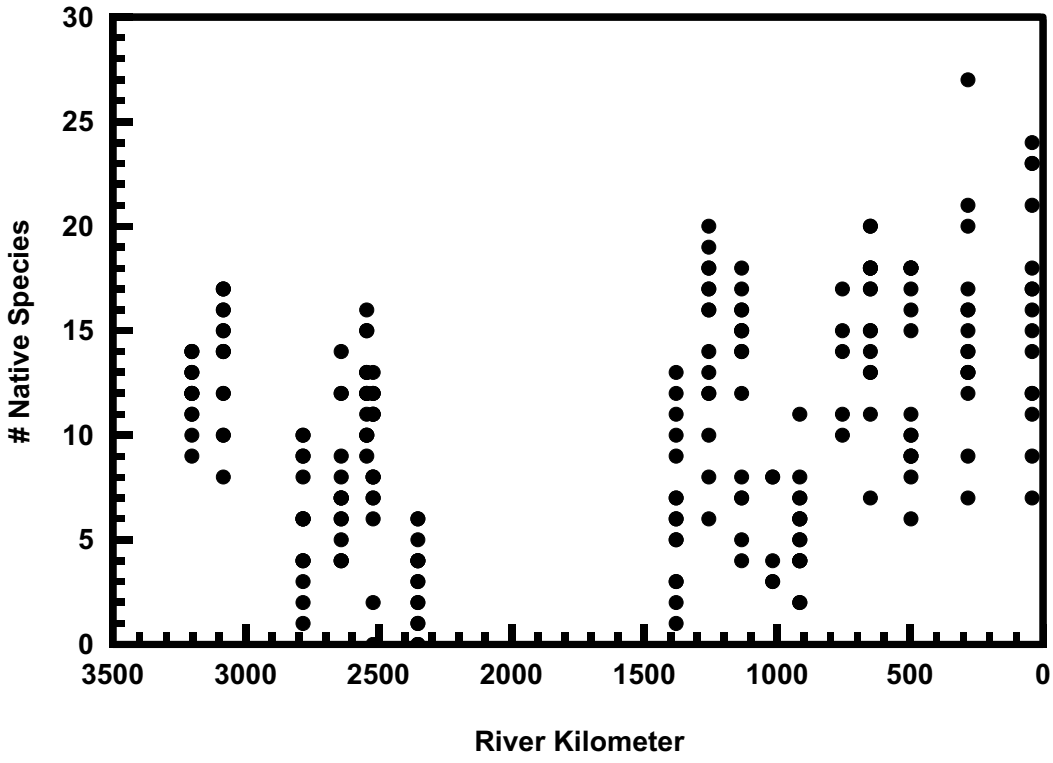

Figure 21. Scatter plot of the number of native species by river kilometer.

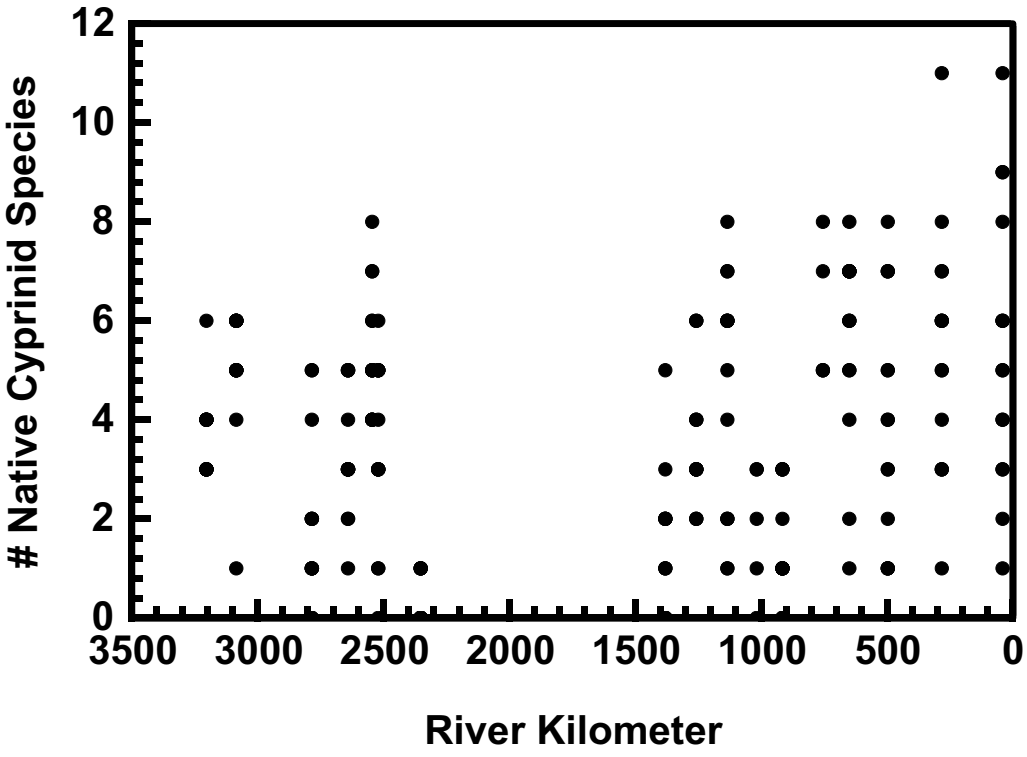

Figure 22. Scatter plot of the number of native cyprinid species by river kilometer.

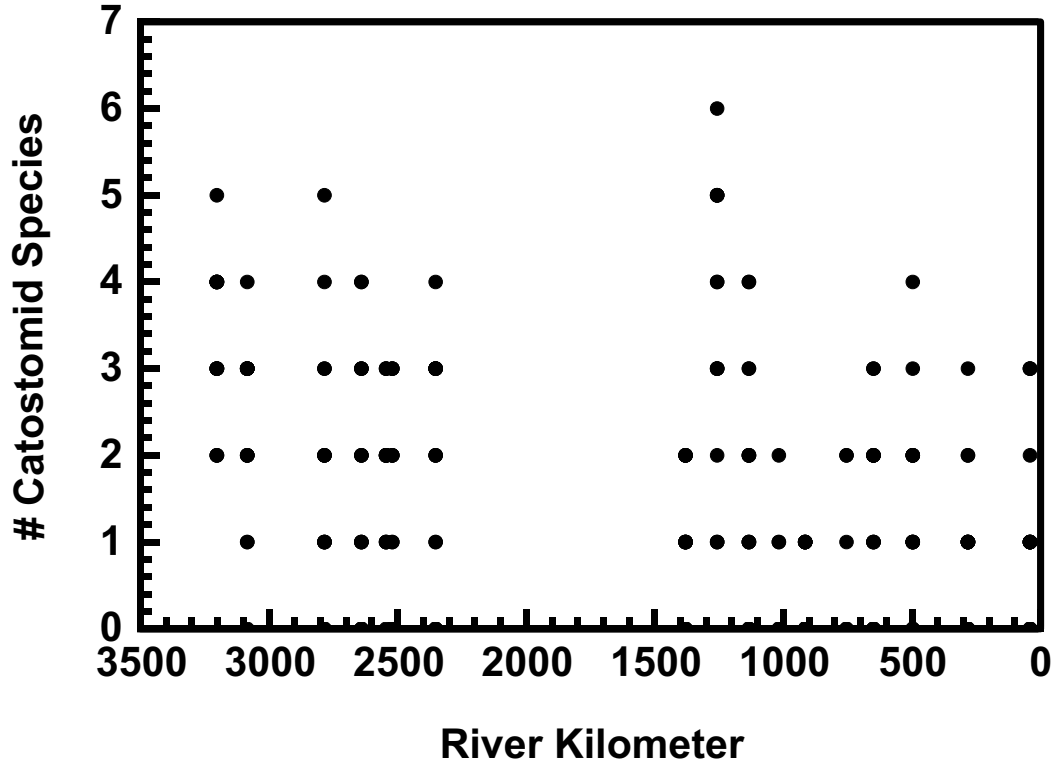

Figure 23. Scatter plot of the number of catostomid species by river kilometer.

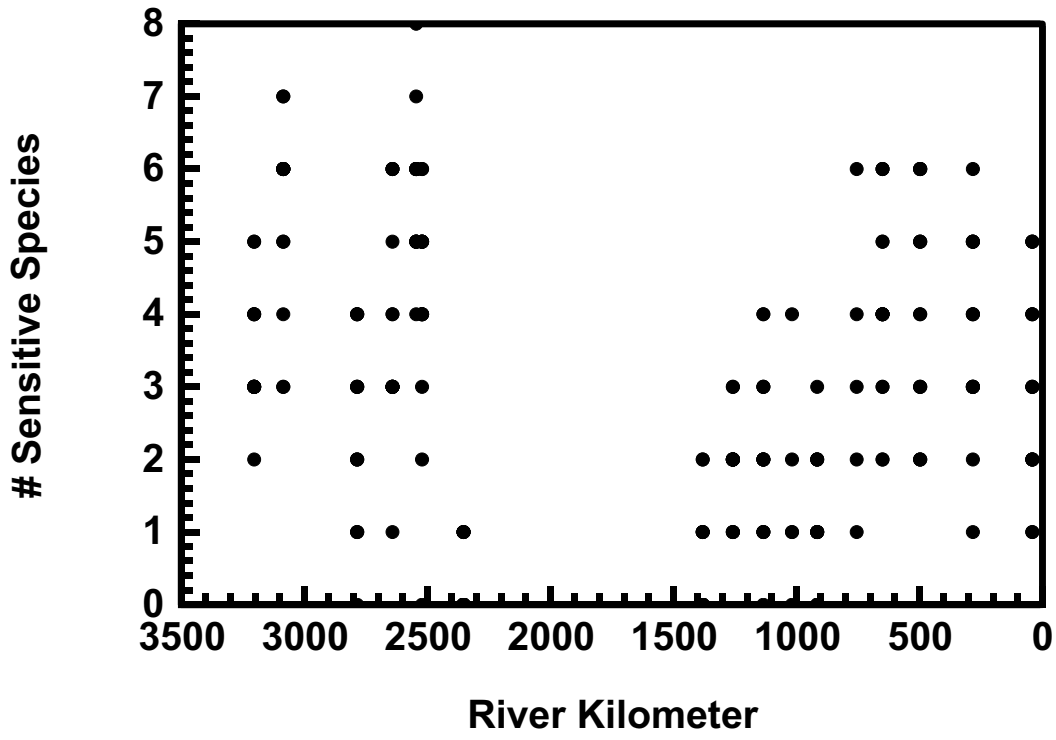

Figure 24. Scatter plot of the number of sensitive species by river kilometer.

Maximum number of species = (-0.0043 x rkm) + 29.112

For the total number of native cyprinid species, the "maximum species richness" value is calculated by the equation:

Maximum number of cyprinid species = (-0.0007 x rkm) + 8.0226

These maximum species values (rounded off the nearest whole number) are then divided into the actual number of collected species to obtain a metric score. If a score greater than 1.0 is calculated, the score is reset to 1.0.

Metric redundancy based on metric scores was similar to that observed for the raw data. Only five of the pairwise comparisons had r^2 values over 0.50. The number of native species was again somewhat redundant with the number of native cyprinids ($r^2 = 0.63$, $p < 0.01$) and CPUE ($r^2 = 0.58$, $p < 0.01$). The percentage of individuals that were members of the large-river faunal group was somewhat redundant with the percentage of pelagophilous and lithopelagophilous spawners ($r^2 = 0.51$, $p < 0.01$) and the percent sensitive species metric ($r^2 = 0.51$, $p < 0.01$). The number of native cyprinid species was also weakly correlated with the number of sensitive species ($r^2 = 0.54$, $p < 0.01$).

The CV was reduced when metric scores were analyzed for all three metrics that had raw-data CVs over 100%. The CVs for the percent catostomids, percent round-bodied catostomids, and percent DELT metrics were 70%, 102%, and 115%, respectively.

Given the relatively good performance of most metrics, some degree of subjective judgment had to be used in selecting the final metrics for inclusion into the IBI. A total of 12 metrics were retained and seven were deleted from the final IBI (Table 2). The total number of native species, the percent large river faunal group, and number of native cyprinids were all retained because of their overall performance in terms of responsiveness, redundancy, and variability, and the fact that they have been used successfully in other warmwater and large-river indices.

The percent of round-bodied catostomids was retained while the number of catostomid species and

Table 11. Equations used for scoring individual IBI metrics. Scores that are >1.0 were scored as 1.0.

Metric	Scoring Equation
Number Native Species	Number species / calculated max species number
Percent Large River Faunal Group	Percent large river faunal group / 87.4
Number Native Cyprinids	Number cyprinid species / calculated max species number
Percent Round-Bodied Catostomids	Percent round-bodied catostomids / 8.8
Number Sensitive Species	Number sensitive species / 6
Percent Tolerant	(100 - percent tolerant) / 97.6
Percent Detritivores and Filter-Feeders	(100 - Percent detritivores and filter-feeders) / 98.3
Percent Insectivorous Cyprinids	Percent insectivorous cyprinids / 66.4
Percent Top Carnivore	Percent top carnivore / 3.3
CPUE	CPUE / 120.6
Percent Introduced	(100 – percent introduced) / 98.9
Percent DELT	1.2 + (-0.4 * Percent DELT)
Total IBI Score	**(Sum of metrics / 12) * 100**

percent of catostomids were both dropped for the final IBI. Whereas all three metrics performed fairly well, the exclusion of more tolerant catostomid taxa suggested by Simon and Emery (1995) appeared warranted.

The number of sensitive taxa was retained while the percentage of sensitive taxa was dropped. Neither metric appeared to be sensitive to stream size and both discriminated between the least-altered zone and all other zones. The number of sensitive taxa was retained simply because it has been more widely used in previously published indices (e.g., Ohio EPA 1987a, Lyons et al. 1995, Simon and Emery 1995, Hughes et al. 1998). The percent tolerant species metric was also retained.

The percent detritivore and filter-feeding metric and the percent insectivorous cyprinids were both retained. The percent benthic insectivore metric was dropped because it had higher variance than the percent insectivorous cyprinid metric.

The percent top carnivore and CPUE metrics were both retained. Both have performed well in other indices, both discriminated well between the reference sites and the channelized and inter-reservoir zones, and both had CVs less than 100%.

The percent of introduced species metric was retained while the three reproduction metrics were dropped. Whereas some of the reproductive metrics performed as well, or better, than the percent introduced species metric, we believed the uncertainty in reproductive strategy of several species warranted their exclusion at this time. Finally, the percent DELT metric was also retained. This metric discriminated only against the regulated-unchannelized zone and had high CV values for both the raw data and metric scores. These problems have been encountered during development of other indices (Mebane et al. 2003), but this metric was retained anyway. One reason for the high variability may be because of inconsistencies between zones in the identification of DELT characteristics. Additionally, a metric that specifically indicates industrial and sewage outfall is still relevant, even if such areas of localized impact were not sampled in this study.

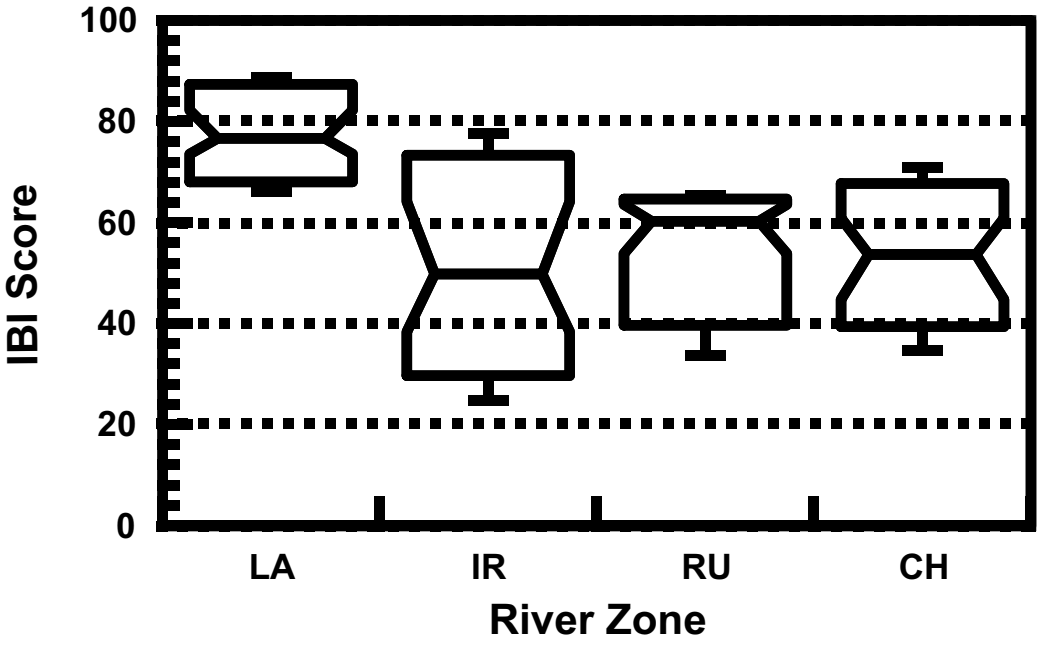

Figure 25. Box plot of IBI scores by river zone. Box plot indicates (from bottom to top) 5th, 10th, 25th, median, 75th, 90th, and 95th percentiles. LA = Least-altered; IR = Inter-reservoir; RU = regulated-unchannelized; CH = channelized.

Biological Condition on the Missouri River

Total IBI scores for the least-altered zone and were significantly higher than the other three zones ($p < 0.05$ for all). The three other river zones were not significantly different from each other. Total scores for the least-altered zone varied from 64 to 91, with a median value of 77 (Figure 25). Total IBI scores in the inter-reservoir zone varied from 0 (two sites where no fish were collected) to 81 with a median value of 50. Total IBI scores in the regulated-unchannelized zone varying from 34 to 65 with a median value of 60. Total IBI scores in the channelized zone varied from 29 to 73, with a median value of 54. The best score was 91 out of a possible 100. This result is not surprising, because some anthropogenic effects occur throughout the basin.

These results are to be expected as metrics were chosen based on their ability to discriminate between the least-altered zone and the other river zones. This type of approach is often criticized as being circular (Karr and Chu 1999). However, the approach is valid for several reasons. First, the warmwater reaches of the Missouri River upstream of Fort Peck Reservoir and the lower Yellowstone River were chosen *a priori* to represent the least-altered conditions based on published literature (Pflieger and Grace 1987; Hesse et al.1989; Hesse and Mestl 1993; White and Bramblett 1993; Hesse 1996) and professional judgment provided by researches familiar with the Missouri River. The data were not examined in order to determine what constituted the least-altered condition. Secondly, candidate metrics were chosen based almost entirely on metrics which have been shown to respond predictably to human influence in many habitats for different fish assemblages across many regions (Miller et al 1988; Oberdorff and Hughes 1992; Lyons et al. 1995, 1996; Hughes et al. 1998) and specifically in large rivers (Ohio EPA 1987a; Ohio EPA 1987b; Simon and Emery 1995; Emery et al. 1999; Simon and Sanders 1999; Lyons et al. 2001; Emery et al. 2003; Mebane et al. 2003).

The argument will persist that the observed differences in metric scores and total IBI scores could just as easily be explained by longitudinal variation in the fish assemblage and not necessarily because of anthropogenic stresses. While there is validity to this argument, repeated observation of patterns is the only method to increase confidence in this method as experimentation is not possible. The development of the Missouri River IBI represents an attempt to apply the IBI concept over a longer distance than attempted previously. However, we did not ignore the concept of fish assemblages changing along a longitudinal gradient. The fact that species richness is expected to increase was considered and incorporated into the metrics where necessary. Additionally, all data were

examined to determine if metrics consistently increased or decreased from upstream to downstream. Consistent changes would perhaps suggest a natural explanation for differences between river zones.

It is difficult to identify what exactly constitutes a "good" or "bad" IBI score without having more quantitative measures of anthropogenic stress throughout the basin. Development of qualitative ratings based on IBI scores is always somewhat subjective. Lyons et al. (2001) simply divided the total IBI score into five evenly divided categories with 0-19 rated very poor, 20-39 rated poor, 40-59 rated fair, 60 to 79 rated good, and 80 to 100 rated excellent. Using these criteria, total scores in the least-altered zone were rated excellent at 36% of the sites and rated good at 64% of the sites. By contrast, the inter-reservoir zone had scores in all categories, excellent (3%), good (37%), fair (32%), poor (25%), and very poor (3%). The regulated-unchannelized zone was rated good at 60% of the sites, fair at 33% of the sites, and poor at 7% of the sites. The channelized zone was rated good at 31% of the sites, fair at 58% of the sites, and poor at 11% of the sites.

Metric Contribution to Index Score

If each metric contributed evenly to the overall IBI score, the individual contribution of each metric would be approximately 8.3% (Table 12). Individual metrics contributed 4.3 to 10.6% of the total IBI score for the least-altered sites. For all of the other zones combined, individual metrics contributed 2.5 to 14.9% of the total IBI score. The percent of round-bodied catostomids metric had the lowest average contribution to the total IBI score for both the reference sites and disturbed sites (Table 12). The percent detritivore and filter-feeding metric had the highest average contribution to the total IBI score for reference sites whereas the percent introduced species metric had the highest overall contribution to the total IBI score for disturbed sites.

Despite the wider range in the overall relative contribution of individual metrics for disturbed sites, relative contributions of the metrics to the total IBI score were similar for disturbed and reference sites. Six of the 12 metrics differed by 2.0 % or less whereas the remaining six metrics differed by 2.1 to 4.6%.

Table 12. Relative contributions to the overall IBI score for least-altered and disturbed zones for each of the 12 metrics.

Metric	Average relative IBI Contribution (%) for reference sites	Average relative IBI Contribution (%) for disturbed sites
Number Native Species	8.6	6.9
Percent Large River Faunal Group	9.1	7.2
Number Native Cyprinids	8.2	6.8
Percent Round-Bodied Catostomids	4.3	2.5
Number Sensitive Species	8.5	6.4
Percent Tolerant	10.2	12.2
Percent Detritivores and Filter-Feeders	10.6	14.6
Percent Insectivorous Cyprinids	7.4	4.8
Percent Top Carnivore	5.4	4.5
CPUE	6.7	4.5
Percent Introduced	10.3	14.9
Percent DELT	10.5	14.6

LIMITATIONS AND RECOMMENDATIONS

The index of biotic integrity developed for the Missouri River appears to be able to discriminate between the best attainable conditions in the upper basin and conditions within zones where human activities such as channelization, dredging, flow regulation, and urbanization have affected the aquatic community. The Missouri River index of biotic integrity holds a great deal of promise in aiding researchers and managers in such tasks as identifying areas of high biological condition in need of preservation, identifying areas where rehabilitation or mitigation is needed, and evaluating the effectiveness of mitigation and rehabilitation efforts. Whereas we believe this index is a valid indicator of biological integrity for the entire warmwater portion of the Missouri River, future sampling on the Missouri River will serve to verify and refine this index.

The first major limitation is that the Missouri River IBI was developed with data only collected from the main channel habitats. Therefore, the Missouri River IBI can only be applied to data collected from mainstem habitats at this time with any certainty. A large proportion of the fish captured during the Missouri River benthic fish study were captured in off-channel habitats (e.g., side channels) but these data were excluded in the development of the index because off-channel habitats were not sampled in the same locations as the main channel sites. Future sampling should include any discrete habitat units within the defined study site. What effects that the inclusion of these habitat types will have on the individual metrics or the index itself is unknown and will have to be reevaluated.

Another limitation of the index is that it is untested. Generally, a portion of data is removed during index development and then the removed data are used to calculate index values to see if they are categorized correctly. This was not done for one major reason. In order to determine if sites are being categorized correctly, finer scale resolution of anthropogenic stresses is necessary. While very large scale disturbances are known (i.e., regulated, channelized, etc.) a gradient of disturbance was not determined *a priori.* For example, are negative affects on the fish community greater for channelization or regulated flow? Additionally, localized disturbances (e.g., urbanization, cattle grazing, etc.) were not known for the individual sites. Therefore, without better definition of large-scale and localized disturbances for each site, validation data are not useful at this time. The potential for further refinement of the Missouri River IBI exists if more site-specific information can be incorporated to develop a gradient of anthropogenic stresses. Detailed information on large-scale impacts (percent land use, distance from dam, etc.) and site specific impacts (eroding banks, point-source effluent, etc.) should provide finer resolution on the responses of individual metrics to anthropogenic stress.

Lastly, the index should be viewed as an initial step in determining what the current and best attainable conditions are at a site given our current knowledge. For example, although the potential species richness of native cyprinids in the Missouri River is much higher near the mouth than at sites above Fort Peck Reservoir (Appendix A), this highest score for this metric only varies from six species at the most upstream sites to eight at the mouth. This is almost certainly a reflection of increases in species richness being dampened by anthropogenic affects. Only further investigation of the fish assemblage in areas where restoration activities have occurred or flow regimes have been changed will determine if the ceiling has been set too low in terms of the biological condition that can be attained. For the present, the Missouri River index of biotic integrity should be used as a tool for analyzing independent data sets from future surveys.

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Appendix A.

Fish Species collected from 1996 to 1998 on the Missouri River in conjunction with the Missouri River Benthic Fish Project inlcuding native range, habitat notes, reproductive guild, feeding guild, tolerance information, and references.

APPENDIX A

FISH SPECIES COLLECTED FROM 1996 TO 1998 ON THE MISSOURI RIVER IN CONJUNCTION WITH THE MISSOURI RIVER BENTHIC FISH PROJECT INCLUDING NATIVE RANGE, HABITAT NOTES, REPRODUCTIVE GUILD, FEEDING GUILD, TOLERANCE INFORMATION, AND REFERENCES

Scientific Name: *Ichthyomyzon castaneus*
Common Name: chestnut lamprey
Family: Petromyzontidae
Missouri River Distribution: Native to the lower Missouri River near Rulo, NE to the Mississippi River (Sections 21 – 27; ~ rkm 800 – 0). Collected only 2 individuals in Section 25 (~ rkm 354 – 210).
Habitat Notes: Found in various habitats in large rivers, streams, reservoirs (dependent on life stage)
Reproductive Guild: Lithophils (A.2.3)
Feeding Guild: Herbivore – Filter Feeder (ammocoete); Carnivore – Parasite (adult)
Tolerance Notes: Declining as a result of degraded ammocoete habitat but not necessarily related to mainstem modifications.
References: Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Lee et al. 1980; Lyons et al. 1996; Niemela et al. 1999; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Simon and Emery 1995; Tomelleri and Eberle 1990

Scientific Name: *Acipenser fulvescens*
Common Name: lake sturgeon
Family: Acipenseridae
Missouri River Distribution: Native to the lower 1300 km of the Missouri River (Sections 15 – 27); Only five individuals collected in the lower 354 km of the river.
Habitat Notes: Benthic member of the Large River Faunal Group found in pool habitat of large rivers and in lakes.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Invertivore - Benthic
Tolerance Notes: Declining in native range and thought to be intolerant to habitat modifications on the Missouri River.
References: Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987a, b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988; Simon 1999b; Simon and Emery 1995; Thoma 1999; Trautman 1981

Scientific Name: *Scaphirhynchus albus*
Common Name: pallid sturgeon
Family: Acipenseridae
Missouri River Distribution: Native to entire warmwater portion of the Missouri and Yellowstone river (Sections 1 –27). Only four individuals captured with three coming from

below Fort Peck Reservoir in Montana and an additional individual captured between St. Joseph and Kansas City, MO (rkm 708.0 – 591.3). Attempts made not to capture and harass this species in Montana.
Habitat Notes: Benthic member of the Large River Faunal Group found in various habitats and turbid waters.
Reproductive Guild: Undescribed but most likely Lithopelagophils (A.1.2)
Feeding Guild: Invertivore (Carnivore) - Benthic
Tolerance Notes: Federally Endangered species intolerant to large river habitat modification.
References: Cross et al. 1986; Dryer and Sandvol 1993; Hesse et al. 1989; Holton and Johnson 1996; Lee et al. 1980; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988

Scientific Name: *Scaphirhynchus platorynchus*
Common Name: shovelnose sturgeon
Family: Acipenseridae
Missouri River Distribution: Native to entire warmwater portion of the Missouri and Yellowstone rivers (Sections 1 –27). Caught throughout all study sections.
Habitat Notes: Benthic member of the Large River Faunal Group found in various habitats of turbid rivers.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Invertivore - Benthic
Tolerance Notes: Big declines in commercial catch and species of concern throughout some portions of its range in the Missouri River basin.
References: Baxter and Stone 1995; Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Holton and Johnson 1996; Lee et al. 1980; Ohio EPA 1987a, b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988; Simon 1999b; Simon and Emery 1995; Tomelleri and Eberle 1990; Trautman 1981

Scientific Name: *Polydon spathula*
Common Name: paddlefish
Family: Polydontidae
Missouri River Distribution: Native to entire warmwater portions of the Missouri and Yellowstone rivers (Sections 1 –27). Sixteen individuals captured from the Missouri River from Montana to the confluence of the Mississippi River. Gears not adequate to efficiently capture a water column species of this size.
Habitat Notes: Open water member of the Large River Faunal Group in variable habitats of turbid rivers.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Planktivore – Filter Feeder
Tolerance Notes: Thought to be declining after initial post-reservoir “boom” and considered a species of concern in several Missouri River States.
References: Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Holton and Johnson 1996; Lee et al. 1980; Ohio EPA 1987a, b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Rankin and Yoder 1999; Simon 1999b; Simon and Emery 1995; Thoma 1999; Tomelleri and Eberle 1990; Trautman 1981

Scientific Name: *Lepisosteus oculatus*
Common Name: spotted gar
Family: Lepisosteidae
Missouri River Distribution: Native to the mainstem Mississippi River and its tributaries. Uncommon to the mainstem Missouri River above Saint Louis but reported occasionally. One individual captured in Section 21 (rkm 801.3 – 708.0) and one captured in Section 25 (rkm 354.0 – 209.8).
Habitat Notes: Water column species preferring clear, vegetated, pool areas.
Reproductive Guild: Phytophils (A.1.5)
Feeding Guild: Carnivore – Whole Body
Tolerance Notes: Not as tolerant as other gar species, but not considered intolerant.
References: Cross et al. 1986; Goldstein and Simon 1999; Lee et al. 1980; Mundahl and Simon 1999; Ohio EPA 1987a, b; Pflieger 1975; Robison and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Thoma 1999; Trautman 1981

Scientific Name: *Lepisosteus osseus*
Common Name: longnose gar
Family: Lepisosteidae
Missouri River Distribution: Native to lower third of the Missouri River from Gavins Point Dam (~ rkm 1300) to confluence of the Mississippi River. Found commonly in the lower basin during this study.
Habitat Notes: Water column species found in rivers of various size preferring vegetated pool habitats.
Reproductive Guild: Phytolithophils (A.1.4)
Feeding Guild: Carnivore – Whole Body
Tolerance Notes: Considered more tolerant to habitat degradation and pollution than other gars.
References: Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Jennings et al. 1999; Lee et al. 1980; Minns et al. 1994; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Simon and Emery 1995; Thoma 1999; Trautman 1981

Scientific Name: *Lepisosteus platostomus*
Common Name: shortnose gar
Family: Lepisosteidae
Missouri River Distribution: Native from present day Fort Peck Reservoir and the Yellowstone River to the Mississippi River confluence (Sections 8 – 27; ~ rkm 2850 – 0). Caught from Wolf Point, MT (rkm 2740) to the Mississippi River confluence (rkm 0).
Habitat Notes: Water column member of the Large River Faunal Group preferring vegetated pool habitat.
Reproductive Guild: Phytophils (A.1.5)
Feeding Guild: Carnivore – Whole Body
Tolerance Notes: Considered a species of concern in Montana but has likely always been rare. The species is common in the lower river.

References: Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Holton and Johnson 1996; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Robison and Buchanan 1988; Shields et al. 1995; Simon 1999b; Simon and Emery 1995; Thoma 1999

Scientific Name: *Amia calva*
Common Name: Bowfin
Family: Amiidae
Missouri River Distribution: Cross et al. (1986) believe the species to be introduced to the Missouri River whereas Lee et al. (1980) and Hesse et al. (1989) indicate the species is native to the Missouri River as far upstream as South Dakota. Only two individuals were collected and both were near the confluence of the Mississippi River so can be considered native due to their proximity to the Mississippi River where they are certainly native.
Habitat Notes: Found in variable sized rivers and streams with a preference towards clear, vegetated, sluggish waters.
Reproductive Guild: Phytophils (B.2.5)
Feeding Guild: Carnivore – Whole Body
Tolerance Notes: Tolerant to low dissolved oxygen and extreme temperatures.
References: Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Lee et al. 1980; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Robison and Buchanan 1988; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999

Scientific Name: *Hiodon alosoides*
Common Name: goldeye
Family: Hiodontidae
Missouri River Distribution: Native throughout all warmwater portions of the Missouri and Yellowstone rivers (Sections 1 –27). Caught throughout all study areas.
Habitat Notes: Water column member of the Large River Faunal Group.
Reproductive Guild: Lithopelagophils (A.1.1)
Feeding Guild: Invertivore - Drift
Tolerance Notes: Species is believed to be tolerant to industrial pollution and habitat altercations associated with tailwaters of reservoirs.
References: Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Rankin and Yoder 1999; Simon 1999b; Simon and Emery 1995

Scientific Name: *Alosa chrysochloris*
Common Name: skipjack herring
Family: Clupeidae
Missouri River Distribution: Native to at least the lower 870 km of the Missouri River. Species was found rarely in the lower 590 km of the river from Kansas City, MO, downstream.
Habitat Notes: Water column member of the Large River Faunal Group
Reproductive Guild: Phytolithophils (A.1.4)
Feeding Guild: Planktivore – Filter Feeder

Tolerance Notes: Considered intolerant to some stresses not relevant to the Missouri River.
References: Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Lee et al. 1980; Mundahl and Simon 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Scott 1999; Simon 1999b; Simon and Emery 1995; Tomelleri and Eberle 1990; Trautman 1981

Scientific Name: *Dorosoma cepedianum*
Common Name: gizzard shad
Family: Clupeidae
Missouri River Distribution: The northern extent of this species range is uncertain, but may have extended into the Dakotas. Fish has been extensively stocked as a forage fish making historical distributions unclear. The native distribution was assumed to be from Fort Randal Dam to the Mississippi River.
Habitat Notes: Water column species that thrives in impoundments and prefers pool habitat in running waters.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Herbivore – Filter Feeder
Tolerance Notes: Tolerant to lentic conditions imposed by impoundments.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Baxter and Stone 1995; Bramblett and Fausch 1991; Cross et al. 1986; Crumby et al. 1990; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Schrader 1989; Scott 1999; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Simon and Emery 1995; Smogor and Angermeier 1999; Trautman 1981

Scientific Name: *Dorosoma petenense*
Common Name: threadfin shad
Family: Clupeidae
Missouri River Distribution: Introduced to the Missouri River drainage.
Habitat Notes: A water column species associated with large rivers.
Reproductive Guild: Phytophils (A.1.5)
Feeding Guild: Planktivore – Filter Feeder
Tolerance Notes: No indication of tolerance or intolerance to anthropogenic stesses.
References: Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Robison and Buchanan 1988; Scott 1999; Simon 1999b; Shields et al. 1995; Simon and Emery 1995

Scientific Name: *Campostoma oligolepis*
Common Name: largescale stoneroller
Family: Cyprinidae
Missouri River Distribution: Native to the lower 350 km of the Missouri River. Only two individuals were captured in Section 25 (rkm 354.0 – 209.8).
Habitat Notes: Generally found in smaller rivers and streams in riffle habitats.
Reproductive Guild: Lithophils (A.2.3)
Feeding Guild: Herbivore – Particulate Feeder

Tolerance Notes: No tolerance or intolerance to anthropogenic stresses pertinent to the Missouri River.
References: Bowen et al. 1998; Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Jennings et al. 1999; Lee et al. 1980; Niemela et al. 1999; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Simon 1999b

Scientific Name: *Carassius auratus*
Common Name: goldfish
Family: Cyprinidae
Missouri River Distribution: Introduced from Asia with some reproducing populations reported in the Missouri River basin. Only five individuals collected from segments 22 and 23 (rkm 708.0 – 402.2).
Habitat Notes: Benthic pool species preferring shallow water with dense vegetation.
Reproductive Guild: Phytophils (A.1.5)
Feeding Guild: Invertivore/Herbivore - Benthic
Tolerance Notes: Described as tolerant to many types of anthropogenic stresses.
References: Angermeier and Karr 1986; Brown 1971; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Hughes and Gammon 1987; Hughes et al. 1998; Karr et al. 1986; Lee et al. 1980; Lever 1996; Mundahl and Simon 1999; Ohio EPA 1987b; Pflieger 1975; Robison and Buchanan 1988; Scott and Crossman 1973; Simon 1999b; Simon and Emery 1995; Thoma 1999; Trautman 1981

Scientific Name: *Couesius plumbeus*
Common Name: lake chub
Family: Cyprinidae
Missouri River Distribution: Native in the upper basin in Montana and into North and South Dakota (~ rkm 3300 – 2200). Generally restricted to smaller tributaries. Only one specimen collected in Segment 3 near the confluence of the Judith River (~ rkm 3200).
Habitat Notes: Generally prefers clearer waters of smaller tributary streams and rivers.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Goldstein and Simon (1999) classify as Invertivore/Planktivore with trophic subclass being undescribed. Evidence suggests Invertivore - Drift.
Tolerance Notes: No tolerances or intolerances described.
References: Baxter and Stone 1995; Brown 1971; Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Holton and Johnson 1996; Lee et al. 1980; Page and Burr 1991; Scott and Crossman 1973; Simon 1999b

Scientific Name: *Ctenopharyngodon idella*
Common Name: grass carp
Family: Cyprinidae
Missouri River Distribution: Introduced from Asia. Reproducing populations now present in the mainstem Missouri River from South Dakota to the Mississippi River confluence. Collected from Gavins Point Dam to the mouth (~ rkm 1300 – 0)
Habitat Notes: Benthic large river species preferring pool habitats.
Reproductive Guild: Pelagophils (A.1.1)
Feeding Guild: Herbivore – Particulate Feeder

Tolerance Notes: Tolerant to extremes in temperature, alkalinity, and low dissolved oxygen.
References: Baxter and Stone 1995; Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Hughes et al. 1998; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Simon 1999b; Goldstein and Simon 1999

Scientific Name: *Cyprinella lutrensis*
Common Name: red shiner
Family: Cyprinidae
Missouri River Distribution: Native from current day Garrison Dam to the Mississippi River (~ rkm 2200 – 0). Collected within this range.
Habitat Notes: Benthic pool-dwelling species found in a variable sized streams and rivers.
Reproductive Guild: Speleophils (A.2.4)
Feeding Guild: Invertivore/Herbivore - Benthic
Tolerance Notes: Tolerant to extreme environmental conditions (except cold).
References: Baxter and Stone 1995; Bramblett and Fausch 1991; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Hesse et al. 1989; Karr et al. 1986; Ohio EPA 1987b; Pflieger 1975; Robison and Buchanan 1988; Schrader 1989; Shields et al. 1995; Simon 1999b; Simon and Emery 1995

Scientific Name: *Cyprinella spiloptera*
Common Name: spotfin shiner
Family: Cyprinidae
Missouri River Distribution: Native to the lower ~200 km of the Missouri River. Introduced elsewhere throughout the basin. All individuals captured were outside of native range from Fort Randall Dam (rkm 1415.9) to the Grand River (rkm 402.2).
Habitat Notes: Found mostly in highly turbid, smaller streams.
Reproductive Guild: Speleophils (A.2.4)
Feeding Guild: Invertivore/Detritivore – Particulate Feeder
Tolerance Notes: Tolerant to pollution.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Cross et al. 1986; Halliwell et al. 1999; Karr 1981; Karr et al. 1986; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Robison and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999; Trautman 1981

Scientific Name: *Cyprinus carpio*
Common Name: Common Carp
Family: Cyprinidae
Missouri River Distribution: Introduced from Asia and widespread throughout the Missouri River Basin.
Habitat Notes: Benthic species found in a variety of running and standing waters. Prefers slower velocities and pool habitats.
Reproductive Guild: Phytolithophils (A.1.4)
Feeding Guild: Invertivore/Detritivore – Benthic/Filter Feeder
Tolerance Notes: Tolerant to a variety of environmental and anthropogenic stresses.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Baxter and Stone 1995; Bramblett and Fausch 1991; Brown 1971; Cross et al.1986; Crumby et al. 1990;

Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Holton and Johnson 1996; Hughes and Gammon 1987; Hughes et al. 1998; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Lyons et al. 1996; Maret 1999; Niemela et al. 1999; Oberdorff and Hughes 1992; Ohio EPA 1987b; Page and Burr 1991; Panek 1987; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988; Sanders et al. 1999; Scott 1999; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Simon and Emery 1995; Smogor and Angermeier 1999; Thoma 1999; Trautman 1981; Whittier 1999

Scientific Name: *Hybognathus argyritis*
Common Name: western silvery minnow
Family: Cyprinidae
Missouri River Distribution: Native to entire warmwater reaches of the Missouri and Yellowstone rivers (Segments 1 –27). Generally grouped as *Hybognathus* spp. because of identification problems but the majority of fish identified were *H. argyritis.*
Habitat Notes: Member of the Large River Faunal Group with little specific habitat information available.
Reproductive Guild: Undescribed but most likely pelagophils (A.1.1)
Feeding Guild Undescribed but most likely detritivore – particulate feeder.
Tolerance Notes: Species of concern throughout some portions of its range and may be intolerant to modifications caused by damming and channelization.
References: Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Page and Burr 1991; Pflieger 1971; Platania and Altenbach 1998; Simon 1999b; Tomelleri and Eberle 1990

Scientific Name: *Hybognathus hankinsoni*
Common Name: brassy minnow
Family: Cyprinidae
Missouri River Distribution: Native to most of the warmwater reaches of the Missouri and Yellowstone Rivers except the lowest portions in Missouri (Segments 1 –25).
Habitat Notes: More common in smaller streams than other *Hybognathus* species.
Reproductive Guild: Phytophils (A.1.5)
Feeding Guild: Planktivore/Detritivore – Particulate Feeder
Tolerance Notes: A species of concern throughout parts of its range.
References: Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Karr et al. 1986; Page and Burr 1991; Pflieger 1975; Schrader 1989; Simon 1999b; Tomelleri and Eberle 1990

Scientific Name: *Hybognathus placitus*
Common Name: plains minnow
Family: Cyprinidae
Missouri River Distribution: Native to entire warmwater reaches of the Missouri and Yellowstone rivers (Segments 1 –27). Generally grouped as *Hybognathus* spp. because of identification problems.
Habitat Notes: Member of Large River Faunal Group with little other habitat information.
Reproductive Guild: Undescribed but likely pelagophils (A.1.1)
Feeding Guild: Herbivore – Particulate Feeder
Tolerance Notes: Species of concern throughout parts of its range.

References: Bramblett and Fausch 1991; Cross et al. 1986; Goldstein and Simon 1999; Hesse et al 1989; Page and Burr 1991; Pflieger 1971; Platania and Altenbach 1998; Robison and Buchanan 1988; Simon 1999b; Tomelleri and Eberle 1990

Scientific Name: *Hypophthalmichthys nobilis*
Common Name: bighead carp
Family: Cyprinidae
Missouri River Distribution: Introduced to the lower Missouri River from eastern Siberia and China. Now reproducing in the lower Missouri River.
Habitat Notes: Water column of large rivers.
Reproductive Guild: Pelagophils (A.1.1)
Feeding Guild: Invertivore/Planktivore – Filter Feeder
Tolerance Notes: Tolerant to eutrophication.
References: Goldstein and Simon 1999; Lever 1996; Robison and Buchanan 1988

Scientific Name: *Luxilus chrysocephalus*
Common Name: striped shiner
Family: Cyprinidae
Missouri River Distribution: Native to only the lowest reaches of the Missouri River (Segment 27). Only one individual collected above the Mississippi River confluence.
Habitat Notes: Prefers rocky, clear streams.
Reproductive Guild: Lithophils (A.2.3)
Feeding Guild: Invertivore – Drift
Tolerance Notes: None reported.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Bowen et al. 1998; Cross et al. 1986; Crumby et al. 1990; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Robison and Buchanan 1988; Scott 1999; Shields et al. 1995; Simon 1999b; Smogor and Angermeier 1999

Scientific Name: *Luxilus cornutus*
Common Name: common shiner
Family: Cyprinidae
Missouri River Distribution: Reported to be native into the Dakotas near present day Gavins Point Dam to the Mississippi River confluence. Only two specimens collected from near the confluence with the Mississippi River (Segement 27).
Habitat Notes: Found in pool habitat of small to midsize streams.
Reproductive Guild: Lithophils (A.2.3)
Feeding Guild: Invertivore - Drift
Tolerance Notes: No tolerances or intolerances relevant to Missouri River conditions.
References: Angermeier and Karr 1986; Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Karr 1981; Karr et al. 1986; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Schrader 1989; Simon 1999b; Smogor and Angermeier 1999; Trautman 1981; Whittier 1999

Scientific Name: *Macrhybopsis aestivalis*
Common Name: speckled chub
Family: Cyprinidae
Missouri River Distribution: Native to the Missouri River from the Mississippi River confluence to just upstream of the Platte River (Segment 18 – 27).
Habitat Notes: Member of the Large River Faunal Group.
Reproductive Guild: Pelagophils (A.1.1)
Feeding Guild: Invertivore - Benthic
Tolerance Notes: Intolerant to pollution.
References: Bowen et al. 1998; Bramblett and Fausch 1991; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Hesse et al. 1989; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Rankin and Yoder 1999; Robison and Buchanan 1988; Scott 1999; Simon and Emery 1995

Scientific Name: *Macrhybopsis gelida*
Common Name: sturgeon chub
Family: Cyprinidae
Missouri River Distribution: Native to entire warmwater reaches of the Missouri and Yellowstone rivers (Segments 1 –27).
Habitat Notes: Benthic member of the Large River Faunal Group.
Reproductive Guild: Undescribed pelagophils or lithopelagophils (A.1.1 or A.1.2)
Feeding Guild: Undescribed but most likely Invertivore – Benthic.
Tolerance Notes: Species of concern in several Missouri River states and Federal candidate species.
References: Carlander 1969; Cross et al. 1986; Halliwell et al. 1999; Hesse et al. 1989; Holton and Johnson 1996; Lee et al. 1980; Niemela et al. 1999; Page and Burr 1991; Pflieger 1971; Platania and Altenbach 1998

Scientific Name: *Macrhybopsis meeki*
Common Name: sicklefin chub
Family: Cyprinidae
Missouri River Distribution: Native to entire warmwater reaches of the Missouri and Yellowstone rivers (Segments 1 –27). Captured throughout all study areas during this study.
Habitat Notes: Benthic member of the Large River Faunal Group with little additional habitat information.
Reproductive Guild: Undescribed pelagophils or lithopelagophils (A.1.1 or A.1.2)
Feeding Guild: Undescribed but most likely Invertivore – Benthic.
Tolerance Notes: Species of concern in several Missouri River states and Federal candidate species.
References: Carlander 1969; Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Holton and Johnson 1996; Lee et al. 1980; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Platania and Altenbach 1998; Reich and Elsen 1979; Robison and Buchanan 1988; Simon 1999b

Scientific Name: *Macrhybopsis storeriana*

Common Name: silver chub
Family: Cyprinidae
Missouri River Distribution: Native from the Mississippi River into South Dakota near present day Fort Randall Dam (Segments 14 – 27).
Habitat Notes: Benthic member of the Large River Faunal Group.
Reproductive Guild: Lithopelagophils or pelagophils(A.1.1 or A.1.2)
Feeding Guild: Planktivore/Invertivore - Benthic
Tolerance Notes: Conflicting information regarding tolerance and intolerance to anthropogenic stresses.
References: Bowen et al. 1998; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Karr et al. 1986; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Platania and Altenbach 1998; Robison and Buchanan 1988; Scott 1999; Simon 1999b; Simon and Emery 1995; Thoma 1999

Scientific Name: *Margariscus margarita*
Common Name: pearl dace
Family: Cyprinidae
Missouri River Distribution: Native to the upper basin with rare occurrences through the Dakotas and Nebraska.
Habitat Notes: Pool dwelling species preferring clear, cool, streams.
Reproductive Guild: Unknown but most likely a Lithophils (B.1.3)
Feeding Guild: Invertivore/Carnivore - Drift
Tolerance Notes: Small stream species so no tolerances pertinent to the Missouri River.
References: Baxter and Stone 1995; Brown 1971; Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Holton and Johnson 1996; Lee et al. 1980; Page and Burr 1991; Scott and Crossman 1973

Scientific Name: *Notemigonus crysoleucas*
Common Name: golden shiner
Family: Cyprinidae
Missouri River Distribution: Discrepancies in literature, but it is probably native from South Dakota/Iowa/Nebraska "corner," whereas others indicate native to near Montana border. Montana authors were uncertain. Considered native to all segments for the purposes of this study.
Habitat Notes: Wide ranging, pool dwelling species.
Reproductive Guild: Phytophils (A.1.5)
Feeding Guild: Invertivore/Herbivore – Particulate Feeder
Tolerance Notes: Considered tolerant to a variety of anthropogenic stresses.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Brown 1971; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Holton and Johnson 1996; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Lyons et al. 1996; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Simon and Emery 1995; Smogor and Angermeier 1999; Thoma 1999; Tomelleri and Eberle 1990; Trautman 1981; Whittier 1999

Scientific Name: *Notropis atherinoides*
Common Name: emerald shiner
Family: Cyprinidae
Missouri River Distribution: Native to the entire warmwater reaches of the Missouri River (segments 1 – 27). Nearly 15,000 individuals collected throughout the study sections.
Habitat Notes: Member of the Large River Faunal Group found in a variety of habitats.
Reproductive Guild: Pelagophils (A.1.1)
Feeding Guild: Planktivore – Particulate Feeder
Tolerance Notes: Potentially moderately tolerant to anthropogenic effects of damming.
References: Angermeier and Karr 1986; Baxter and Stone 1995; Brown 1971; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Hesse et al. 1989; Holton and Johnson 1996; Karr et al. 1986; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Scott 1999; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Simon and Emery 1995

Scientific Name: *Notropis blennius*
Common Name: river shiner
Family: Cyprinidae
Missouri River Distribution: Native from the Mississippi River into South Dakota (segments 14 – 27).
Habitat Notes: Pool dwelling member of the Large River Faunal Group.
Reproductive Guild: Undescribed but classified as Lithopelagophils (A.1.2) based on observational data.
Feeding Guild: Invertivore - Drift
Tolerance Notes: No information on tolerance.
References: Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Robison and Buchanan 1988; Simon 1999b; Trautman 1981

Scientific Name: *Notropis boops*
Common Name: bigeye shiner
Family: Cyprinidae
Missouri River Distribution: Native to lower portion of the basin (segments 19 – 27).
Habitat Notes: Generally found in smaller, clearer streams in the basin.
Reproductive Guild: Uncertain but potentially Lithophils (A.1.3)
Feeding Guild: Invertivore - Drift
Tolerance Notes: Only sensitive to ambient Missouri River conditions.
References: Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Rankin and Yoder 1999; Robison and Buchanan 1988; Trautman 1981

Scientific Name: *Notropis buchanani*
Common Name: ghost shiner
Family: Cyprinidae

Missouri River Distribution: Native to the lower basin below the Platte River (segments 19 – 27).
Habitat Notes: Pool dwelling species in variable sized rivers and streams.
Reproductive Guild: Undescribed but classified as Lithopelagophils (A.1.2)
Feeding Guild: Undescribed but classified as Invertivore – drift based on available information.
Tolerance Notes: None listed.
References: Angermeier and Karr 1986; Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Simon 1999b

Scientific Name: *Notropis dorsalis*
Common Name: bigmouth shiner
Family: Cyprinidae
Missouri River Distribution: Native from South Dakota to the Mississippi River (segments 15 – 27).
Habitat Notes: Prefers shallow, silt/sand bottomed, prairie streams.
Reproductive Guild: Undescribed but Pelagophils (A.1.1) suggested.
Feeding Guild: Invertivore - Benthic
Tolerance Notes: Considered tolerant by some but no indication of what it is tolerant to.
References: Baxter and Stone 1995; Bramblett and Fausch 1991; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Schrader 1989; Simon 1999b

Scientific Name: *Notropis hudsonius*
Common Name: spottail shiner
Family: Cyprinidae
Missouri River Distribution: Perhaps native to the James River and Sioux River drainages (segments 14 – 18) but certainly introduced elsewhere.
Habitat Notes: Member of the Large River Faunal Group found in various habitats. Because of its questionable native range it was not classified as a native Large River Faunal Group species.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Invertivore/Planktivore - Drift
Tolerance Notes: Nothing relevant to Missouri River stresses.
References: Baxter and Stone 1995; Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Jennings et al. 1999; Karr et al. 1986; Lee et al.1980; Lyons et al. 1996; Minns et al. 1994; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Scott and Crossman 1973; Simon 1999b; Simon and Emery 1995; Smogor and Angermeier 1999; Whittier 1999

Scientific Name: *Notropis shumardi*
Common Name: silverband shiner
Family: Cyprinidae

Missouri River Distribution: Native to South Dakota but only collected in segments 22 and 27.
Habitat Notes: Member of the Large River Faunal Group. No other information.
Reproductive Guild: Undescribed but classified as Lithopelagophils (A.1.2)
Feeding Guild: Undescribed but classified as Invertivore/Planktivore – Drift.
Tolerance Notes: No information.
References: Cross et al. 1986; Hesse et al. 1989; Lee et al. 1980; Page and Burr 1991; Pflieger 1971; Robison and Buchanan 1988; Simon and Emery 1995

Scientific Name: *Notropis stramineus*
Common Name: sand shiner
Family: Cyprinidae
Missouri River Distribution: Native throughout all study areas but less common in the upper basin (segments 1 – 27).
Habitat Notes: Found in variable habitats in variable sized streams and rivers.
Reproductive Guild: Undescribed but classified as Lithopelagophils (A.1.2) based on observational data.
Feeding Guild: Invertivore/Detritivore – Particulate Feeder
Tolerance Notes: No tolerance ranking assigned.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Baxter and Stone 1995; Bramblett and Fausch 1991; Brown 1971; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Karr 1981; Karr et al. 1986; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Robison and Buchanan 1988; Schrader 1989; Scott and Crossman 1973; Smogor and Angermeier 1999; Trautman 1981

Scientific Name: *Notropis volucellus*
Common Name: mimic shiner
Family: Cyprinidae
Missouri River Distribution: Native to the lower Missouri River only (segments 25 –27) and introduced elsewhere.
Habitat Notes: Member of Large River Faunal Group.
Reproductive Guild: Phytophils (A.1.5)
Feeding Guild: Invertivore/Herbivore – Particulate Feeder
Tolerance Notes: No information on tolerance ranking.
References: Angermeier and Karr 1986; Bowen et al. 1998; Cross et al. 1986; Crumby et al. 1990; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Rankin and Yoder 1999; Robison and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Simon 1999b; Simon and Emery 1995; Smogor and Angermeier 1999; Thoma 1999; Trautman 1981

Scientific Name: *Phanacobius mirabilis*
Common Name: suckermouth minnow
Family: Cyprinidae

Missouri River Distribution: Native into South Dakota but only collected from Kansas City, MO, down to the Mississippi River (segments 23 – 27).
Habitat Notes: Found in variable sized rivers and streams preferring riffle habitats.
Reproductive Guild: Undescribed but classified as Lithopelagophils (A.1.2) based on observational data.
Feeding Guild: Invertivore - Benthic
Tolerance Notes: Only intolerant to ambient Missouri River conditions.
References: Angermeier and Karr 1986; Baxter and Stone 1995; Bramblett and Fausch 1991; Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Schrader 1989; Trautman 1981

Scientific Name: *Phoxinus eos*
Common Name: northern redbelly dace
Family: Cyprinidae
Missouri River Distribution: Native in the upper basin into South Dakota (segments 1 – 14).
Habitat Notes: Pool dwelling species in variable sized streams and rivers.
Reproductive Guild: Phytolithophils (A.1.4)
Feeding Guild: Invertivore/Planktivore - Drift
Tolerance Notes: No tolerance ranking.
References: Brown 1971; Cross et al. 1986; Goldstein and Simon 1989; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Lee et al. 1980; Niemela et al. 1999; Page and Burr 1991; Schrader 1989; Scott and Crossman 1973; Simon 1999b; Tomelleri and Eberle 1990

Scientific Name: *Pimephales notatus*
Common Name: bluntnose minnow
Family: Cyprinidae
Missouri River Distribution: Appears to be native to southern South Dakota down (segment 15 – 27) but considered native in segment 14 because of uncertain historical distribution.
Habitat Notes: Mostly pool dwelling species of variable sized streams and rivers.
Reproductive Guild: Steleophils (B.2.7)
Feeding Guild: Detritivore – Particulate Feeder
Tolerance Notes: Tolerant to pollution and other anthropogenic stresses.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Cross et al. 1986; Crumby et al. 1990; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Karr 1981; Karr et al. 1986; Lee et al. 1980; Leonard and Orth 1986; Lyons et al. 1996; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Simon and Emery 1995; Smogor and Angermeier 1999; Thoma 1999; Trautman 1981

Scientific Name: *Pimephales promelas*
Common Name: fathead minnow

Family: Cyprinidae
Missouri River Distribution: Native throughout all study sections of the Missouri and Yellowstone rivers (segments 1 –27).
Habitat Notes: Found in a wide variety of habitat type in various sized streams and rivers.
Reproductive Guild: Steleophils (B.2.7)
Feeding Guild: Detritivore/Insectivore – Particulate Feeder
Tolerance Notes: Tolerant to a variety of environmental and anthropogenic stresses.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Baxter and Stone 1995; Bramblett and Fasuch 1991; Brown 1971; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Holton and Johnson 1996; Hughes et al. 1998; Jennings et al. 1999; Karr 1981; Karr et al. 1986; Lee et al. 1980; Lyons et al. 1996; Maret 1999; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Schrader 1989; Scott and Crossman 1973; Simon 1999b; Simon and Emery 1995; Smogor and Angermeier 1999; Thoma 1999; Trautman 1981; Whittier 1999

Scientific Name: *Pimephales vigilax*
Common Name: bullhead minnow
Family: Cyprinidae
Missouri River Distribution: Native only near the confluence to the Mississippi River (segment 27), introduced elsewhere.
Habitat Notes: Prefers sluggish pools and backwaters of streams and rivers.
Reproductive Guild: Steleophils (B.2.7)
Feeding Guild: Herbivore/Invertivore – Drift
Tolerance Notes: No tolerance or intolerance for ambient Missouri River conditions.
References: Cross et al. 1986; Goldstein and Simon 1999; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Scott 1999; Shields et al. 1995; Simon 1999b; Simon and Emery 1995; Trautman 1981

Scientific Name: *Platygobio gracilis*
Common Name: flathead chub
Family: Cyprinidae
Missouri River Distribution: Native throughout all study sections of the Missouri and Yellowstone rivers (segments 1 –27).
Habitat Notes: Member of the Large River Faunal Group seemingly benthic orientated until reaching larger sizes when it can be found in the open water.
Reproductive Guild: Undescribed but classified as Lithopelagophils (A.1.2).
Feeding Guild: Invertivore - Drift
Tolerance Notes: Species noted for its decline in the lower basin. Classified as intolerant based on status in lower Missouri River states.
References: Baxter and Stone 1995; Bramblett and Fausch 1991; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Hesse et al. 1989; Lee et al. 1980; Niemela et al. 1999; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988; Scott and Crossman 1973; USFWS 1994

Scientific Name: *Rhinichthys cataractae*

Common Name: longnose dace
Family: Cyprinidae
Missouri River Distribution: Native in the Missouri River basin into Nebraska. Found in the mainstem Missouri River into western North Dakota (segments 1 – 10).
Habitat Notes: Benthic dwelling species preferring riffle habitat.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Invertivore - Benthic
Tolerance Notes: Nothing relevant to Missouri River.
References: Angermeier and Karr 1986; Baxter and Stone 1995; Bramblett and Fausch 1991; Brown 1971; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Holton and Johnson 1996; Hughes and Gammon 1987; Hughes et al. 1998; Jennings et al. 1999; Lee et al. 1980; Leonard and Orth 1986; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Rankin and Yoder 1999; Schrader 1989; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999; Trautman 1981

Scientific Name: *Semotilus atromaculatus*
Common Name: creek chub
Family: Cyprinidae
Missouri River Distribution: Native from eastern Montana to the Mississippi River (segments 6-27).
Habitat Notes: Prefers smaller, clearer streams but found in a variety of habitats and various sized rivers and streams.
Reproductive Guild: Lithophils (A.2.3)
Feeding Guild: Invertivore/Carnivore - Drift
Tolerance Notes: Tolerant to pollution.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Baxter and Stone 1995; Bramblett and Fausch 1991; Brown 1971; Cross et al. 1986; Crumby et al. 1990; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Holton and Johnson 1996; Jennings et al. 1999; Karr 1981; Lee et al. 1980; Leonard and Orth 1986; Lyons et al. 1996; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Schrader 1989; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Simon and Emery 1995; Smogor and Angermeier 1999; Thoma 1999; Tomelleri and Eberle 1990; Whittier 1999

Scientific Name: *Carpiodes carpio*
Common Name: river carpsucker
Family: Catostomidae
Missouri River Distribution: Native throughout all study sections of the Missouri and Yellowstone rivers (segments 1 –27).
Habitat Notes: Benthic species preferring pool habitats of larger streams and rivers.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Planktivore/Detritivore – Filter Feeder
Tolerance Notes: Considered tolerant in some historically clear water areas, but not pertinent to the Missouri River.

References: Angermeier and Karr 1986; Bramblett and Fausch 1991; Brown 1971; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Hesse et al. 1989; Holton and Johnson 1996; Karr et al. 1986; Lee et al. 1980; Lyons et al. 1995; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Schrader 1989; Scott 1999; Shields et al. 1995; Simon 1999b; Simon and Emery 1995; Tomelleri and Eberle 1990; Trautman 1981

Scientific Name: *Carpiodes cyprinus*
Common Name: quillback
Family: Catostomidae
Missouri River Distribution: Native from the Mississippi River into South Dakota (segments 14 – 27).
Habitat Notes: Benthic pool species found in various sized rivers and streams.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Invertivore/Detritivore – Benthic/Filter Feeder
Tolerance Notes: Considered tolerant by many IBI authors, but no indication of specific tolerances.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Cross et al. 1986; Emery et al. 1999; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Minns et al. 1994; Mundahl and Simon1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Scott and Crossman 1973; Scott 1999; Simon 1999b; Simon and Emery 1995

Scientific Name: *Carpiodes velifer*
Common Name: highfin carpsucker
Family: Catostomidae
Missouri River Distribution: Native from the Mississippi River to current day Gavins Point Dam (segments 15 – 27).
Habitat Notes: Benthic species preferring pool habitats of various sized rivers and streams.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Detritivore – Filter Feeder
Tolerance Notes: Considered intolerant to turbidity and siltation, not pertinent to the Missouri River.
References: Angermeier and Karr 1986; Bowen et al. 1998; Cross et al. 1986; Emery et al. 1999; Goldstein and Simon 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Scott 1999; Simon 1999b; Tomelleri and Eberle 1990

Scientific Name: *Catostomus catostomus*
Common Name: longnose sucker
Family: Catostomidae
Missouri River Distribution: Native in the upper basin from central Montana into South Dakota (segments 1 – 12).
Habitat Notes: Benthic pool species inhabiting various sized rivers and streams.
Reproductive Guild: Lithopelagophils (A.1.2)

Feeding Guild: Invertivore - Benthic
Tolerance Notes: Species of concern in some states but no intolerances related to stresses pertinent to the Missouri River.
References: Baxter and Stone 1995; Bramblett and Fausch 1991; Brown 1971; Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Lee et al. 1980; Mundahl and Simon 1999; Ohio EPA 1987b; Page and Burr 1991; Schrader 1989; Simon 1999b; Thoma 1999; Tomelleri and Eberle 1990

Scientific Name: *Catostomus commersoni*
Common Name: white sucker
Family: Catostomidae
Missouri River Distribution: Native throughout all study sections of the Missouri and Yellowstone rivers (segments 1 –27).
Habitat Notes: Benthic species found in various sized rivers and streams.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Invertivore/Detritivore – Benthic/Filter Feeder
Tolerance Notes: Considered tolerant to a wide variety of habitat alterations.
References: Baxter and Stone 1995; Bramblett and Fausch 1991; Cross et al. 1986; Crumby et al. 1990; Emery et al. 1999; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Holton and Johnson 1996; Jennings et al. 1999; Karr 1981; Karr et al. 1986; Lee et al. 1980; Leonard and Orth 1986; Lyons et al. 1996; Minns et al. 1994; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Schrader 1989; Scott and Crossman 1973; Simon 1999b; Simon and Emery 1995; Smogor and Angermeier 1999; Tomelleri and Eberle 1990; Trautman 1981; Whittier 1999

Scientific Name: *Cycleptus elongatus*
Common Name: blue sucker
Family: Catostomidae
Missouri River Distribution: Native throughout all study sections of the Missouri and Yellowstone rivers (segments 1 –27).
Habitat Notes: Member of the Large River Faunal Group inhabiting strong current areas of deep chutes and the main channel.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Invertivore /Herbivore – Benthic (plant ingestion may be incidental)
Tolerance Notes: Declining throughout its native range.
References: Cross et al. 1986; Emery et al. 1999; Frenzel and Swanson 1996; Goldstein and Simon 1999; Hesse et al. 1989; Holton and Johnson 1996; Karr et al. 1986; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Rankin and Yoder 1999; Robison and Buchanan 1988; Scott 1999; Simon 1999b; Simon and Emery 1995; Tomelleri and Eberle 1990

Scientific Name: *Hypentelium nigricans*
Common Name: northern hog sucker
Family: Catostomidae

Missouri River Distribution: Apparently only native from the Mississippi River to central Missouri (segments 23 – 27). One individual captured approximately 500 rkm above Kansas City, MO, between the confluences of the Big Sioux and Little Sioux rivers (segment 17) indicating an introduction or straying.
Habitat Notes: Benthic species preferring riffle habitat in clear gravel streams.
Reproductive Guild: Lithophils (A.1.3)
Feeding Guild: Invertivore/Herbivore - Benthic
Tolerance Notes: Intolerant to pollution and stream modifications in clear streams. However, not expected in Missouri River mainstem.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Cross et al. 1986; Crumby et al. 1990; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Lyons et al. 1996; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Rankin and Yoder 1999; Robison and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999

Scientific Name: *Ictiobus bubalus*
Common Name: smallmouth buffalo
Family: Catostomidae
Missouri River Distribution: Native throughout all study sections of the Missouri and Yellowstone rivers (segments 1 –27).
Habitat Notes: Benthic Large River Faunal Group member.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Invertivore/Herbivore - Benthic
Tolerance Notes: Appears to be tolerant to a variety of stresses.
References: Brown 1971; Cross et al. 1986; Emery et al. 1999; Frenzel and Swanson 1996; Goldstein and Simon 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Mundahl and Simon 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Scott 1999; Shields et al. 1995; Simon 1999b; Simon and Emery 1995

Scientific Name: *Ictiobus cyprinellus*
Common Name: bigmouth buffalo
Family: Catostomidae
Missouri River Distribution: Native throughout all study sections of the Missouri and Yellowstone rivers (segments 1 –27).
Habitat Notes:
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Invertivore - Drift
Tolerance Notes: Appears to be tolerant to a variety of stresses.
References: Brown 1971; Cross et al. 1986; Emery et al. 1999; Frenzel and Swanson 1996; Goldstein and Simon 1999; Hesse et al. 1989; Holton and Johnson 1996; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988; Scott and Crossman 1973; Simon 1999b; Simon and Emery 1995; Tomelleri and Eberle 1990; Trautman 1981

Scientific Name: *Ictiobus niger*

Common Name: black buffalo
Family: Catostomidae
Missouri River Distribution: Native from the Mississippi River to near present day Gavins Point dam (segments 15 – 27).
Habitat Notes: Found in larger streams and rivers in a variety of habitats.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Undescribed, but observational data suggest Invertivore/Herbivore - Drift
Tolerance Notes: Conflicting reports of tolerance to anthropogenic stresses while others claim intolerance to habitat modification. No classification for this study.
References: Cross et al. 1986; Emery et al. 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988; Scott 1999; Shields et al. 1995; Simon 1999b; Simon and Emery 1995

Scientific Name: *Moxostoma carinatum*
Common Name: river redhorse
Family: Catostomidae
Missouri River Distribution: Native from the Mississippi River to the confluence of the Big Sioux River (segments 17 – 27) but historical distribution appears to have been disjunct.
Habitat Notes: Benthic species preferring clearer waters of various sized rivers.
Reproductive Guild: Lithophils (A.1.3)
Feeding Guild: Invertivore - Benthic
Tolerance Notes: Some authors list moderate tolerances to pollution, silt and turbidity.
References: Bowen et al. 1998; Cross et al. 1986; Emery et al. 1999; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Mundahl and Simon 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Rankin and Yoder 1999; Robison and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Simon 1999b; Tomelleri and Eberle 1990; Thoma 1999; Trautman 1981

Scientific Name: *Moxostoma erythrurum*
Common Name: golden redhorse
Family: Catostomidae
Missouri River Distribution: Native from current day Gavins Point Dam to the Mississippi River with a sporadic distribution.
Habitat Notes: Benthic pool species preferring smaller rivers and moderate to larger size streams.
Reproductive Guild: Lithophils (A.1.3)
Feeding Guild: Invertivore - benthic
Tolerance Notes: Some authors categorize as intolerant but no indication of what it is intolerant to.
References: Cross et al. 1986; Crumby et al. 1990; Emery et al. 1999; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Pflieger 1975; Scott 1999; Rankin and Yoder 1999; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999

Scientific Name: *Moxostoma macrolepidotum*

Common Name: shorthead redhorse
Family: Catostomidae
Missouri River Distribution: Native throughout all study sections of the Missouri and Yellowstone rivers (segments 1 –27).
Habitat Notes: Benthic pool dwelling species found in various sized streams and rivers.
Reproductive Guild: Lithophils (A.1.3)
Feeding Guild: Invertivore - Benthic
Tolerance Notes: Conflicting reports in the literature. No classification for the purposes of this study.
References: Cross et al. 1986; Emery et al. 1999; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Minns et al. 1994; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Rankin and Yoder 1999; Robison and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999

Scientific Name: *Ameiurus melas*
Common Name: black bullhead
Family: Ictaluridae
Missouri River Distribution: Native from the Mississippi River to near, or into eastern Montana. Northwestern extent of the species range is uncertain. Based on information available, considered native from the Mississippi to present-day Lake Sakakawea (segments 12 – 27) and introduced elsewhere.
Habitat Notes: Benthic species found in ponds and pools of various sized streams and rivers.
Reproductive Guild: Steleophils (B.2.7)
Feeding Guild: Invertivore/Carnivore – Benthic/Whole Body
Tolerance Notes: Tolerant to pollution and low dissolved oxygen conditions.
References: Baxter and Stone 1995; Bramblett and Fausch 1991; Brown 1971; Cross et al. 1986; Crumby et al. 1990; Frenzel and Swanson 1996; Goldstein and Simon 1999; Holton and Johnson 1996; Hughes et al. 1998; Karr et al. 1986; Lee et al. 1980; Lyons et al. 1996; Maret 1999; Mundahl and Simon 1999; Niemela et al. 1999; Oberdorff and Hughes 1992; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Robison and Buchanan 1988; Sanders et al. 1999; Scott 1999; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Smogor and Angermeier 1999; Tomelleri and Eberle 1990; Trautman 1981;

Scientific Name: *Ameiurus natalis*
Common Name: yellow bullhead
Family: Ictaluridae
Missouri River Distribution: Native from current day Fort Randall Dam to the Mississippi River (segments 14 – 27). Introduced elsewhere.
Habitat Notes: Benthic pool dwelling species found in various sized streams, rivers, and ponds.
Reproductive Guild: Steleophils (B.2.7)
Feeding Guild: Invertivore/Carnivore – Benthic/Whole Body
Tolerance Notes: Considered tolerant by many authors but not well defined.
References: Brown 1971; Cross et al. 1986; Crumby et al. 1990; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Holton and Johnson 1996; Hughes and

Gammon 1987; Hughes et al. 1998; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Lyons et al. 1996; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Simon and Emery 1995; Smogor and Angermeier 1999; Thoma 1999; Whittier 1999

Scientific Name: *Ictalurus furcatus*
Common Name: blue catfish
Family: Ictaluridae
Missouri River Distribution: Possibly native from the Mississippi River into South Dakota (segments 14 – 27) but only collected from the Platte River down (segments 19 – 27).
Habitat Notes: Benthic, pool dwelling member of the Large River Faunal Group.
Reproductive Guild: Steleophils (B.2.7)
Feeding Guild: Invertivore/Carnivore – Benthic/Whole Body
Tolerance Notes: Species has declined in abundance, most noticeably in the northernmost portion of its range. Appears to be intolerant to the effects of dams.
References: Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Ohio EPA 1987b; Pflieger 1971; Pflieger 1975; Scott 1999; Simon 1999b; Simon and Emery 1995; Trautman 1981

Scientific Name: *Ictalurus punctatus*
Common Name: channel catfish
Family: Ictaluridae
Missouri River Distribution: Native throughout all study sections of the Missouri and Yellowstone rivers (segments 1 –27).
Habitat Notes: Benthic pool dwelling species found in a various sized streams and rivers.
Reproductive Guild: Steleophils (B.2.7)
Feeding Guild: Invertivore/Carnivore – Benthic/Whole Body
Tolerance Notes: Species may be moderately tolerant to pollution, but not enough information to classify for certain.
References: Baxter and Stone 1995; Bramblett and Fausch 1991; Brown 1971; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Holton and Johnson 1996; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Maret 1999; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Schrader 1989; Scott 1999; Shields et al. 1995; Simon 1999b; Simon and Emery 1995; Trautman 1981

Scientific Name: *Noturus exilis*
Common Name: slender madtom
Family: Ictaluridae
Missouri River Distribution: Native to the lower basin (segment 17 – 27)
Habitat Notes: Riffle dwelling species preferring small to medium streams.
Reproductive Guild: Steleophils (B.2.7)
Feeding Guild: Invertivore/Detritivore – Benthic/Particulate Feeder
Tolerance Notes: Intolerant to habitat modifications of small streams, not a large river species.

References: Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Simon 1999b; Tomelleri and Eberle 1990

Scientific Name: *Noturus flavus*
Common Name: stonecat
Family: Ictaluridae
Missouri River Distribution: Native throughout all study sections of the Missouri and Yellowstone rivers (segments 1 –27).
Habitat Notes: Benthic riffle species found in various sized streams and rivers.
Reproductive Guild: Steleophils (B.2.7)
Feeding Guild: Invertivore/Carnivore – Benthic/Whole Body
Tolerance Notes: No tolerance or intolerance relating to large river stresses.
References: Angermeier and Karr 1986; Baxter and Stone 1995; Cross et al. 1986; Crumby et al. 1990; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Holton and Johnson 1996; Karr et al. 1986; Lee et al. 1980; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Rankin and Yoder 1999; Robison and Buchanan 1988; Schrader 1989; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999; Trautman 1981

Scientific Name: *Noturus gyrinus*
Common Name: tadpole madtom
Family: Ictaluridae
Missouri River Distribution: Native from Mississippi River to somewhere near the Platte River (segments 19 – 27). Only one collected in segment 22.
Habitat Notes: Benthic species preferring vegetated pools in variable sized streams.
Reproductive Guild: Steleophils (B.2.7)
Feeding Guild: Invertivore/Planktivore – Benthic/Particulate Feeder
Tolerance Notes: No good sense of historical abundance to assess status of this species.
References: Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Karr et al. 1986; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999; Trautman 1981; Whittier 1999

Scientific Name: *Noturus nocturnus*
Common Name: freckled madtom
Family: Ictaluridae
Missouri River Distribution: Native to the lowest reaches of the Missouri River (segments 26 – 27).
Habitat Notes: Benthic riffle species found in small to medium sized rivers.
Reproductive Guild: Steleophils (B.2.7)
Feeding Guild: Invertivore - Benthic
Tolerance Notes: No indication of tolerances or intolerances.
References: Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Page and Burr 1991; Robison and Buchanan 1988; Simon 1999b

Scientific Name: *Pylodictis olivaris*
Common Name: flathead catfish
Family: Ictaluridae
Missouri River Distribution: Native from the Mississippi River into at least South Dakota (segments 14 – 27) and possible into North Dakota (segment 12).
Habitat Notes: Benthic species found in variety of habitats in medium to large rivers.
Reproductive Guild: Steleophils (B.2.7)
Feeding Guild: Invertivore/Carnivore – Drift/Whole Body
Tolerance Notes: Potentially intolerant to tailwater conditions but little information available.
References: Angermeier and Karr 1986; Bramblett and Fausch 1991; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Mundahl and Simon 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Scott 1999; Shields et al. 1995; Simon 1999b; Simon and Emery 1995

Scientific Name: *Esox americanus*
Common Name: grass pickerel
Family: Esocidae
Missouri River Distribution: Native from the Mississippi River to current day Gavins Point Dam (segments 15 – 27).
Habitat Notes: Benthic pool dwelling species preferring clearer, smaller streams with abundant vegetation.
Reproductive Guild: Phytophils (A.1.5)
Feeding Guild: Invertivore/Carnivore – Drift/Whole Body
Tolerance Notes: Some authors consider intolerant but generally absent from large rivers
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Mundahl and Simon 1999; Ohio EPA 1987b; Page and Burr 1991; Robison and Buchanan 1988; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999; Trautman 1981

Scientific Name: *Esox lucius*
Common Name: northern pike
Family: Esocidae
Missouri River Distribution: Native distribution very uncertain because of excessive stocking of this species throughout the basin. Most accounts agree that the species is introduced into the upper basin in Montana, North Dakota and most of South Dakota (segments 1 – 13). Some authors believe the species persisted in the Missouri River from present day Fort Randall Dam to the Platte River (segments 14 – 18) but were absent from the Platte River to the lower Missouri (segments 19 – 25) only reappearing near the confluence with the Mississippi River (segments 26 – 27).
Habitat Notes: Pool dwelling species preferring vegetated areas of lakes and various sized streams and rivers.
Reproductive Guild: Phytophils (A.1.5)
Feeding Guild: Carnivore – Whole Body
Tolerance Notes: No tolerance ranking.

References: Angermeier and Karr 1986; Baxter and Stone 1995; Brown 1971; Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Holton and Johnson 1996; Jennings et al. 1999; Karr et al. 1986; Lyons et al. 1996; Minns et al. 1994; Mundahl and Simon 1999; Niemela et al. 1999; Oberdorff and Hughes 1992; Ohio EPA 1987b; Pflieger 1975; Robison and Buchanan 1988; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999; Tomelleri and Eberle 1990; Trautman 1981; Whittier 1999

Scientific Name: *Esox masquinongy*
Common Name: muskellunge
Family: Esocidae
Missouri River Distribution: Introduced into the basin from Great Lakes states and north Atlantic states.
Habitat Notes: Prefers heavily vegetated pool habitat.
Reproductive Guild: Phytophils (A.1.5)
Feeding Guild: Carnivore – Whole Body
Tolerance Notes: No tolerance ranking.
References: Angermeier and Karr 1986; Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Lee et al. 1980; Lyons et al. 1996; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Scott and Crossman 1973; Simon 1999b; Thoma 1999; Tomelleri and Eberle 1990

Scientific Name: *Osmerus mordax*
Common Name: rainbow smelt
Family: Osmeridae
Missouri River Distribution: Introduced as a forage fish throughout the basin.
Habitat Notes: Pelagic lake species preferring cool, clear water.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Invertivore/Carnivore – Drift/Whole Body
Tolerance Notes: No tolerance ranking.
References: Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Lee et al. 1980; Minns et al. 1994; Page and Burr 1991; Robison and Buchanan 1988; Scott and Crossman 1973; Simon 1999b; Thoma 1999; Tomelleri and Eberle 1990; Whittier 1999

Scientific Name: *Coregonus artedi*
Common Name: Cisco
Family: Salmonidae
Missouri River Distribution: Introduced into the basin from the upper Mississippi and Great Lakes states.
Habitat Notes: Prefers pools of large rivers and pelagic zone of lakes.
Reproductive Guild: Pelagophils (A.1.1)
Feeding Guild: Planktivore/Invertivore – Particulate Feeder/Drift
Tolerance Notes: No tolerance classification.

References: Goldstein and Simon 1999; Halliwell et al. 1999; Holton and Johnson 1996; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Scott and Crossman 1973; Simon 1999b; Thoma 1999

Scientific Name: *Coregonus clupeaformis*
Common Name: lake whitefish
Family: Salmonidae
Missouri River Distribution: Introduced into reservoirs in the upper basin.
Habitat Notes: Lakes and pool habitats of large rivers.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Invertivore/Carnivore – Particulate Feeder/Whole Body
Tolerance Notes: No tolerance ranking.
References: Brown 1971; Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987b; Scott and Crossman 1973; Simon 1999b; Thoma 1999

Scientific Name: *Oncorhynchus mykiss*
Common Name: rainbow trout
Family: Salmonidae
Missouri River Distribution: Introduced throughout the basin.
Habitat Notes: Cold water species found in a variety of lake, river, and stream habitats.
Reproductive Guild: Lithophils (A.2.3)
Feeding Guild: Invertivore/Carnivore - Drift
Tolerance Notes: No tolerance ranking.
References: Angermeier and Karr 1986; Baxter and Stone 1995; Brown 1971; Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Holton and Johnson 1996; Hughes and Gammon 1987; Hughes et al. 1998; Lyons et al. 1996; Lyons et al. 1996; Lyons et al. 1996; Maret 1999; Minns et al. 1994; Mundahl and Simon 1999; Niemela et al. 1999; Oberdorff and Hughes 1992; Pflieger 1975; Robison and Buchanan 1988; Schrader 1989; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999; Whittier 1999

Scientific Name: *Oncorhynchus tshawytscha*
Common Name: chinook salmon
Family: Salmonidae
Missouri River Distribution: Introduced into reservoirs in the upper basin.
Habitat Notes: Pool dwelling cold water species.
Reproductive Guild: Lithophils (A.2.3)
Feeding Guild: Invertivore/Carnivore - Drift
Tolerance Notes: No tolerance ranking.
References: Cross et al. 1986; Goldstein and Simon 1999; Holton and Johnson 1996; Hughes and Gammon 1987; Hughes et al. 1998; Lyons et al. 1996; Maret 1999; Mundahl and Simon 1999; Ohio EPA 1987b; Scott and Crossman 1973; Simon 1999b; Tomelleri and Eberle 1990

Scientific Name: *Salmo trutta*

Common Name: brown trout
Family: Salmonidae
Missouri River Distribution: European introduction that has been introduced into several areas of the Missouri River basin.
Habitat Notes: Cool to cold-water streams, rivers, and lakes.
Reproductive Guild: Lithophils (A.2.3)
Feeding Guild: Invertivore/Carnivore -Drift
Tolerance Notes: No tolerance ranking.
References: Angermeier and Karr 1986; Cross et al. 1986; Goldstein and Simon 1999; Lee et al. 1980; Lever 1996; Lyons et al. 1996; Maret 1999; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Oberdorff and Hughes 1992; Robison and Buchanan 1988; Schrader 1989; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999

Scientific Name: *Lota lota*
Common Name: burbot
Family: Gadidae
Missouri River Distribution: Native throughout all study sections of the Missouri and Yellowstone rivers (segments 1 –27) but probably always rare in the lower reaches of the Missouri River.
Habitat Notes: Benthic member of the Large River Faunal Group. Species is also associated with lakes.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Invertivore/Carnivore – Whole Body
Tolerance Notes: Little information on tolerance. Species of concern in Missouri but has probably never been abundant.
References: Baxter and Stone 1995; Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Holton and Johnson 1996; Jennings et al. 1999; Lee et al. 1980; Lyons et al. 1996; Mundahl and Simon 1999; Niemela et al 1999; Oberdorff and Hughes 1992; Pflieger 1971; Pflieger 1975; Scott and Crossman 1973; Simon 1999b; Simon and Emery 1995; Thoma 1999; Tomelleri and Eberle 1990;

Scientific Name: *Fundulus diaphanus*
Common Name: banded killifish
Family: Cyprinodontidae
Missouri River Distribution: Very sketchy and contradictory information on historical range. It appears that reports of the species in North Dakota and Iowa may be in the Mississippi drainage. Considered introduced.
Habitat Notes: Prefers quiet, sluggish waters of ponds and pool habitat of streams. Prefers heavily vegetated habitats.
Reproductive Guild: Phytophils (A.1.5)
Feeding Guild: Invertivore/Planktivore - Drift
Tolerance Notes: Generally considered tolerant outside its native range. Appears to be tolerant to low dissolved oxygen conditions and sedimentation. No classification for Missouri River specimens.

References: Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hughes et al. 1998; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999; Whittier 1999

Scientific Name: *Gambusia affinis*
Common Name: mosquitofish (western)
Family: Poeciliidae
Missouri River Distribution: Introduced throughout the basin.
Habitat Notes: Prefers vegetated pool habitats.
Reproductive Guild: Viviparous (C.2.1)
Feeding Guild: Invertivore - Drift
Tolerance Notes: No tolerance ranking.
References: Bramblett and Fausch 1991; Crumby et al 1990; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Karr et al. 1986; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Scott 1999; Shields et al. 1995; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999; Trautman 1981

Scientific Name: *Labidesthes sicculus*
Common Name: brook silverside
Family: Atherinidae
Missouri River Distribution: Native to the lower Missouri (segments 25 – 27) but introduced near the confluence of the Platte River (segment 19).
Habitat Notes: Pool habitat of various sized streams.
Reproductive Guild: Phytolithophils (A.1.4)
Feeding Guild: Planktivore/Invertivore – Particulate Feeder/Drift
Tolerance Notes: No tolerance classification.
References: Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Lee et al. 1980; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Rankin and Yoder 1999; Robison and Buchanan 1988; Rowe 1992; Scott 1999; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Tomelleri and Eberle 1990; Trautman 1981

Scientific Name: *Culaea inconstans*
Common Name: brook stickleback
Family: Gasterosteidae
Missouri River Distribution: Native to the upper basin from near Fort Benton, Montana, to the Platte River (segments 1 – 18).
Habitat Notes: Pool dwelling species preferring, clear, cool streams with heavy vegetation.
Reproductive Guild: Ariadnophils (B.2.4)
Feeding Guild: Planktivore/Invertivore – Particulate Feeder
Tolerance Notes: No tolerance ranking.
References: Bramblett and Fausch 1991; Brown 1971; Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Holton and Johnson 1996; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Schrader 1989; Scott and Crossman 1973; Simon 1999b; Thoma 1999; Tomelleri and Eberle 1990; Trautman 1981

Scientific Name: *Cottus bairdi*
Common Name: mottled sculpin
Family: Cottidae
Missouri River Distribution: Native to Montana above current day Fort Peck Reservoir (segment 1 – 5) and the Ozark region of Missouri.
Habitat Notes: Benthic, riffle dwelling species found in variable sized streams and rivers.
Reproductive Guild: Steleophils (B.2.7)
Feeding Guild: Invertivore - Benthic
Tolerance Notes: No tolerance ranking
References: Angermeier and Karr 1986; Baxter and Stone 1995; Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Lyons et al. 1996; Maret 1999; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999; Trautman 1981

Scientific Name: *Morone americana*
Common Name: white perch
Family: Percichthyidae
Missouri River Distribution: Introduce into basin from the Atlantic coast.
Habitat Notes: Large-river species preferring pool habitat.
Reproductive Guild: Phytolithophils (A.1.4)
Feeding Guild: Invertivore/Carnivore - Drift
Tolerance Notes: No tolerances specifically stated.
References: Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Lee et al. 1980; Minns et al. 1994; Ohio EPA 1987b; Page and Burr 1991; Scott and Crossman 1973; Smogor and Angermeier 1999; Thoma 1999; Whittier 1999

Scientific Name: *Morone chrysops*
Common Name: white bass
Family: Percichthyidae
Missouri River Distribution: Original distribution uncertain. They are native near the Mississippi River but northwestern extent of their range is uncertain. The species is potentially native up to the Nebraska/Iowa portion of the river (segments 17 – 27), but doubtful. May be expanding range upriver from a combination of less turbid conditions (allowing upstream movement) and introductions into upper reservoirs. *Morone saxatilis* x *Morone chrysops* hybrids sampled.
Habitat Notes: Large river species but probably not historically abundant in the Missouri River until turbidities decreased.
Reproductive Guild: Phytolithophils (A.1.4)
Feeding Guild: Invertivore/Carnivore - Drift
Tolerance Notes: Tolerant to habitat modifications associated with dams.
References: Angermeier and Karr 1986; Cross et al. 1986; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Minns et al. 1994; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Scott 1999; Scott and Crossman 1973; Simon 1999b; Simon and Emery 1995

Scientific Name: *Morone mississippiensis*
Common Name: yellow bass
Family: Percichthyidae
Missouri River Distribution: Native to the Mississippi River with potential straying into Missouri River near the mouth as the result of decreased turbidity. Specimens collected in the lowest reaches of the river (segment 27) are considered native but introduced above.
Habitat Notes: Large-river pool dwelling species from the Mississippi River.
Reproductive Guild: Phytolithophils (A.1.4)
Feeding Guild: Invertivore/Carnivore - Drift
Tolerance Notes: No tolerance listed.
References: Cross et al. 1986; Goldstein and Simon 1999; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Scott 1999; Simon 1999b; Simon and Emery 1995

Scientific Name: *Morone saxatilis*
Common Name: striped bass
Family: Percichthyidae
Missouri River Distribution: Introduced into the lower basin. *Morone saxatilis* x *Morone chrysops* hybrids sampled.
Habitat Notes: Pool dwelling large river species.
Reproductive Guild: Phytolithophils (A.1.4)
Feeding Guild: Invertivore/Carnivore – Whole Body
Tolerance Notes: No tolerance information.
References: Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Lee et al. 1980; Mundahl and Simon 1999; Ohio EPA 1987b; Pflieger 1975; Robison and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Simon 1999b

Scientific Name: *Ambloplites rupestris*
Common Name: rock bass
Family: Centrarchidae
Missouri River Distribution: Native to the area near the mouth (segment 27) and some believe populations historically existed in the Sioux River and James River drainages (segment 14 –15). Individuals collected in this area will be considered native, but probably never common in the mainstem because of turbidity.
Habitat Notes: Prefers pool habitat of clear streams and rivers.
Reproductive Guild: Polyphils (B.2.2)
Feeding Guild: Invertivore/Carnivore - Drift
Tolerance Notes: Intolerant to turbidity and sedimentation, which are ambient Missouri River conditions. No tolerance classification given.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Baxter and Stone 1995; Brown 1971; Cross et al. 1986; Crumby et al. 1990; Goldstein and Simon 1999; Halliwell et al. 1999; Holton and Johnson 1996; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Leonard and Orth 1986; Lyons et al. 1996; Minns et al. 1994; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison

and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999; Whittier 1999

Scientific Name: *Lepomis cyanellus*
Common Name: green sunfish
Family: Centrarchidae
Missouri River Distribution: Introduced into the upper basin (segments 1 – 10), native to the lower basin (segments 15 – 27), with the intermediate area being uncertain. Probably never abundant in mainstem but may have maintained populations in tributaries from Mississippi River into North Dakota (segments 11-27). *Lepomis cyanellus* x *Lepomis humilis* and *Lepomis cyanellus* x *Lepomis macrochirus* hybrids sampled.
Habitat Notes: Preferring pool habitats of various sized streams and rivers.
Reproductive Guild: Polyphils (B.2.2)
Feeding Guild: Invertivore/Carnivore – Drift/Whole Body
Tolerance Notes: Considered very tolerant to a variety of anthropogenic stresses.
References: Angermeier and Karr 1986; Baxter and Stone 1995; Bramblett and Fausch 1991; Cross et al. 1986; Crumby et al. 1990; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Holton and Johnson 1996; Hughes et al. 1998; Jennings et al. 1999; Karr 1981; Karr et al. 1986; Lee et al. 1980; Leonard and Orth 1986; Lyons et al. 1996; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Schrader 1989; Scott 1999; Shields et al. 1995; Simon 1999b; Simon and Emery 1995; Smogor and Angermeier 1999; Thoma 1999; Trautman 1981

Scientific Name: *Lepomis gulosus*
Common Name: warmouth
Family: Centrarchidae
Missouri River Distribution: Native only near the confluence with the Mississippi River (segment 27).
Habitat Notes: Water column species preferring pool habitats of streams and ponds.
Reproductive Guild: Lithophils (B.2.3)
Feeding Guild: Invertivore/Carnivore – Drift/Whole Body
Tolerance Notes: No tolerances related to Missouri River.
References: Angermeier and Karr 1986; Cross et al. 1986; Crumby et al. 1990; Goldstein and Simon 1999; Hughes et al. 1998; Lee et al. 1980; Mundahl and Simon 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Scott 1999; Shields et al. 1995; Simon 1999b; Smogor and Angermeier 1999; Tomelleri and Eberle 1990; Tratuman 1981

Scientific Name: *Lepomis humilis*
Common Name: orangespotted sunfish
Family: Centrarchidae
Missouri River Distribution: Upstream extent of historic distribution is uncertain, but most likely no further than present day Gavins Point Dam (segments 15-27). *Lepomis cyanellus* x *Lepomis humilis* hybrids sampled.
Habitat Notes: Water column species preferring pool habitats of various sized streams.

Reproductive Guild: Lithophils (B.2.3)
Feeding Guild: Invertivore - Drift
Tolerance Notes: Tolerant to a variety of anthropogenic and environmental stresses.
References: Bramblett and Fausch 1991; Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Schrader 1989; Simon 1999b

Scientific Name: *Lepomis macrochirus*
Common Name: bluegill
Family: Centrarchidae
Missouri River Distribution: Native to the lower basin in Missouri (segments 26 and 27) and introduced above current day Fort Randall Dam (segments 1-14). Historical distribution in the middle portion of the basin (segments 15 – 25) is uncertain. The species may have maintained populations in the tributaries throughout the middle reaches of the river. *Lepomis cyanellus* x *Lepomis macrochirus* hybrids sampled.
Habitat Notes: Water column species preferring lakes, ponds, and pool habitats of streams.
Reproductive Guild: Polyphils (B.2.2)
Feeding Guild: Invertivore - Drift
Tolerance Notes: Tolerant to a variety of anthropogenic and environmental stresses.
References: Brown 1971; Cross et al. 1986; Crumby et al. 1990; Frenzel and Swasnson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Holton and Johnson 1996; Hughes and Gammon 1987; Hughes et al. 1998; Karr et al. 1986; Lee et al. 1980; Maret 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988; Schrader 1989; Scott 1999; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Smogor and Angermeier 1999; Tomelleri and Eberle 1990; Trautman 1981; Whittier 1999

Scientific Name: *Lepomis megalotis*
Common Name: longear sunfish
Family: Centrarchidae
Missouri River Distribution: Native to the lower Missouri River basin (segments 25 – 27).
Habitat Notes: Pool dwelling species preferring small, clear streams.
Reproductive Guild: Polyphils (B.2.2)
Feeding Guild: Invertivore - Drift
Tolerance Notes: No tolerance ranking.
References: Angermeier and Karr 1986; Cross et al. 1986; Crumby et al. 1990; Goldstein and Simon 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Mundahl and Simon 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Rankin and Yoder 1999; Robison and Buchanan 1988; Scott 1999; Shields et al. 1995; Simon 1999b; Smogor and Angermeier 1999

Scientific Name: *Micropterus dolomieu*
Common Name: smallmouth bass
Family: Centrarchidae

Missouri River Distribution: Probably native to only the lowest portion of the basin (segments 25 – 27).
Habitat Notes: Pool dwelling species found in various sized rivers and streams.
Reproductive Guild: Polyphils (B.2.2)
Feeding Guild: Invertivore/Carnivore – Benthic/Whole Body
Tolerance Notes: No tolerance ranking.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Cross et al. 1986; Crumby et al. 1990; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hughes and Gammon 1987; Hughes et al. 1998; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Lyons et al. 1996; Maret 1999; Minns et al. 1994; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Pflieger 1975; Robison and Buchanan 1988; Scott 1999; Simon 1999b; Smogor and Angermeier 1999; Whittier 1999

Scientific Name: *Micropterus punctulatus*
Common Name: spotted bass
Family: Centrarchidae
Missouri River Distribution: Introduced into the Missouri River basin.
Habitat Notes: Pool dwelling species inhabiting variable sized streams and rivers.
Reproductive Guild: Polyphils (B.2.2)
Feeding Guild: Invertivore/Carnivore – Whole Body
Tolerance Notes: No tolerance category.
References: Angermeier and Karr 1986; Cross et al. 1986; Crumby et al. 1990; Goldstein and Simon 1999; Leonard and Orth 1986; Mundahl and Simon 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Scott 1999; Shields et al. 1995; Simon 1999b; Smogor and Angermeier 1999

Scientific Name: *Micropterus salmoides*
Common Name: largemouth bass
Family: Centrarchidae
Missouri River Distribution: Native to present day Fort Randall Dam to the Mississippi River (segments 14 – 27) and introduced into the upper basin (segments 1 – 13).
Habitat Notes: Pool dwelling water column species found in variable sized streams and rivers.
Reproductive Guild: Polyphils (B.2.2)
Feeding Guild: Invertivore/Carnivore – Whole Body
Tolerance Notes: No tolerance ranking.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hughes and Gammon 1987; Hughes et al. 1998; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Lyons et al. 1996; Maret 1999; Minns et al. 1994; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988; Schrader 1989; Scott 1999; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999; Trautman 1981; Whittier 1999

Scientific Name: *Pomoxis annularis*
Common Name: white crappie

Family: Centrarchidae
Missouri River Distribution: Native from the Mississippi to near the South Dakota – Nebraska border (segment 14 – 27). Introduced in the upper basin (1 – 13).
Habitat Notes: Found mainly in ponds and lakes and pool habitats of various sized streams and rivers.
Reproductive Guild: Phytophils (B.2.5)
Feeding Guild: Invertivore/Carnivore – Whole Body
Tolerance Notes: No tolerance classification.
References: Angermeier and Karr 1986; Angermeier and Schlosser 1987; Cross et al. 1986; Crumby et al. 1990; Frenzel and Swanson 1996; Halliwell et al. 1999; Hughes and Gammon 1987; Hughes et al. 1998; Jennings et al.1999; Karr et al. 1986; Lee et al. 1980; Mundahl and Simon 1999; Page and Burr 1991; Pflieger 1975; Schrader 1989; Shields et al. 1995; Scott 1999; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999; Trautman 1981

Scientific Name: *Pomoxis nigromaculatus*
Common Name: black crappie
Family: Centrarchidae
Missouri River Distribution: Historical native range uncertain. Certainly native to the lower potion of the basin (segments 26 – 27) with fairly good evidence that the species maintained populations in the tributaries from present day Gavins Point Dam to the Platte River (segments 15 – 18).
Habitat Notes: Found mainly in ponds, lakes, and pool habitat of streams and rivers.
Reproductive Guild: Phytophils (B.2.5)
Feeding Guild: Invertivore/Carnivore - Drift
Tolerance Notes: No tolerance classification.
References: Brown 1971; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Holton and Johnson 1996; Hughes et al. 1998; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Maret 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Robison and Buchanan 1988; Schrader 1989; Scott 1999; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999; Trautman 1981; Whittier 1999

Scientific Name: *Ethostoma nigrum*
Common Name: Johnny darter
Family: Percidae
Missouri River Distribution: The northwestern extent of this species historic native distribution is uncertain. It appears to be native from the Missouri River to present day Gavins Point Dam (segments 15 – 27) but may have been native as far into North Dakota as present day Garrison Dam (segments 12 – 27).
Habitat Notes: Benthic species preferring small, clear streams.
Reproductive Guild: Steleophils (B.2.7)
Feeding Guild: Invertivore - Benthic
Tolerance Notes: Not as intolerant to anthropogenic stresses as other darter but no tolerance classification assigned for the Missouri River.

References: Baxter and Stone 1995; Bowen et al. 1998; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Karr 1981; Karr et al. 1986; Lee et al. 1980; Minns et al. 1994; Niemela et al. 1999; Ohio EPA 1999a, b; Page and Burr 1991; Pflieger 1975; Robison and Buchanan 1988; Schrader 1989; Shields et al. 1995; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999; Trautman 1981

Scientific Name: *Perca flavescens*
Common Name: yellow perch
Family: Percidae
Missouri River Distribution: Native populations in the Sioux River and James River drainages and in other tributaries downstream to the Mississippi River (segments 14 – 27).
Habitat Notes: Water column species found in lakes and pool habitats of variable sized streams and rivers.
Reproductive Guild: Phytolithophils (A.1.4)
Feeding Guild: Invertivore/Carnivore - Drift
Tolerance Notes: No tolerance classification.
References: Angermeier and Karr 1986; Baxter and Stone 1995; Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Hughes and Gammon 1987; Hughes et al. 1998; Maret 1999; Minns et al. 1994; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Schrader 1989; Scott 1999; Scott and Crossman 1973; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999; Whittier 1999

Scientific Name: *Percina caprodes*
Common Name: logperch
Family: Percidae
Missouri River Distribution: Native from the Mississippi River to the Missouri - Kansas border area (segments 21 – 27).
Habitat Notes: Benthic species preferring small, clear water streams.
Reproductive Guild: Lithophils (A.2.3)
Feeding Guild: Invertivore - Benthic
Tolerance Notes: No tolerance classification.
References: Angermeier and Karr 1986; Bowen et al. 1998; Cross et al. 1986; Crumby et al. 1990; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Jennings et al. 1999; Karr et al. 1986; Lee et al. 1980; Minns et al. 1994; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1975; Rankin and Yoder 1999; Robison and Buchanan 1988; Scott 1999; Simon 1999b; Smogor and Angermeier 1999; Thoma 1999

Scientific Name: *Sander canadensis*
Common Name: sauger
Family: Percidae
Missouri River Distribution: Native throughout all study sections in the Missouri and Yellowstone rivers (segments 1 –27). *Sander canadensis* x *Sander vitreus* hybrids sampled.
Habitat Notes: Pool dwelling member of the Large River Faunal group.
Reproductive Guild: Lithopelagophils (A.1.2)

Feeding Guild: Invertivore/Carnivore – Whole Body
Tolerance Notes: Species declining in large portions of its historic range.
References: Angermeier and Karr 1986; Baxter and Stone 1995; Brown 1971; Cross et al. 1986; Goldstein and Simon 1999; Hesse et al. 1989; Karr et al. 1986; Lee et al. 1980; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Robison and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Simon 1999b; Simon and Emery 1995; Thoma 1999

Scientific Name: *Sander vitreus*
Common Name: walleye
Family: Percidae
Missouri River Distribution: Historic range uncertain. Introduced into the upper basin (segments 1 – 12), native in the Sioux, James, and White River drainages (segment 13 –18), with an unknown distribution in the lower river (segments 19 – 27). *Sander canadensis* x *Sander vitreus* hybrids sampled.
Habitat Notes: Large river and lake species preferring less turbid waters than most Missouri River large river species.
Reproductive Guild: Lithopelagophils (A.1.2)
Feeding Guild: Invertivore/Carnivore – Whole Body
Tolerance Notes: No tolerance classification for the Missouri River.
References: Angermeier and Karr 1986; Brown 1971; Cross et al. 1986; Goldstein and Simon 1999; Halliwell et al. 1999; Jennings et al. 1999; Karr et al. 1986; Lyons et al. 1996; Maret 1999; Minns et al. 1994; Mundahl and Simon 1999; Niemela et al. 1999; Ohio EPA 1987b; Pflieger 1975; Robison and Buchanan 1988; Scott 1999; Scott and Crossman 1973; Simon 1999b; Simon and Emery 1995; Thoma 1999

Scientific Name: *Aplodinotus grunniens*
Common Name: freshwater drum
Family: Sciaenidae
Missouri River Distribution: Native throughout all study sections of the Missouri and Yellowstone rivers (segments 1 –27).
Habitat Notes: Benthic, pool dwelling member of the Large River Faunal Group.
Reproductive Guild: Pelagophils (A.1.1)
Feeding Guild: Invertivore/Carnivore – Whole Body
Tolerance Notes: Tolerance information not well documented.
References: Cross et al. 1986; Frenzel and Swanson 1996; Goldstein and Simon 1999; Halliwell et al. 1999; Hesse et al. 1989; Lee et al. 1980; Niemela et al. 1999; Ohio EPA 1987b; Page and Burr 1991; Pflieger 1971; Pflieger 1975; Scott 1999; Scott and Crossman 1973; Shields et al. 1995; Simon 1999b; Simon and Emery 1995